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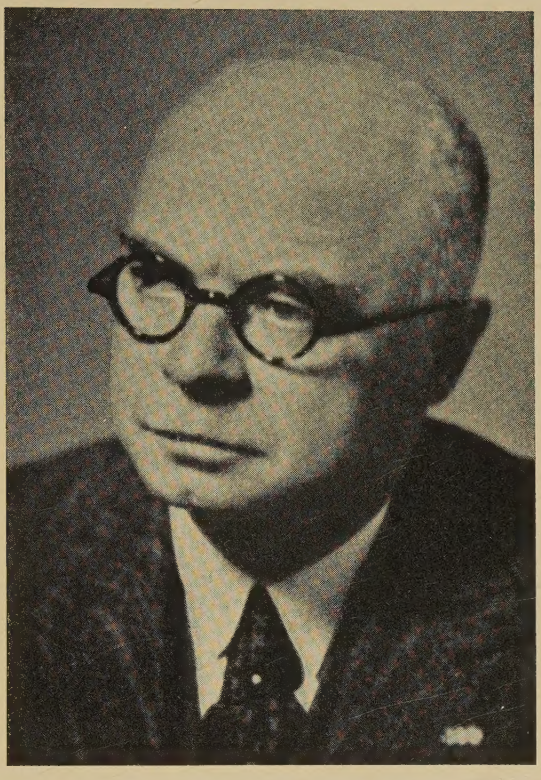

Alfred Willer.

1889—1952.

PROFESSOR Dr. med. et phil. Alfred Willer, geboren am 22. November 1889 in Stettin, wurde am 4. Dezember 1952 nach langjährigem, schweren Herzleiden abberufen. Sein Tod kam seinen Freunden, Mitarbeitern und Schülern überraschend, weil er bis zum letzten Augenblick seinem kranken Körper eine riesige Arbeitsleistung abgetrotzt hatte. Noch am Tage vor seinem Tode hatte er eine Sitzung der Mathematisch-Naturwissenschaftlichen Fakultät der Universität Hamburg als Dekan geleitet.

Willer war bereits 1919 Fischereibeamter (Oberfischmeister) in Königsberg i. Pr. geworden, hatte sich dort habilitiert,

wurde 1925 ao. Professor und gründete das Fischereiinstitut der Universität Königsberg mit der Aussenstelle in Neukuhren am Kurischen Haff und der Versuchs-Teichwirtschaft Perteltnicken.

Eine grosse Zahl fischereiwissenschaftlicher Veröffentlichungen Willers und seiner Schüler sind von diesem Institut ausgegangen. Willer war ein musterhafter und sehr anregender Lehrer und hatte eine Breite der Kenntnisse und Erfahrungen wie selten ein Forscher. Schon die Tatsache, dass er nicht nur naturwissenschaftlich, sondern auch medizinisch geschult war, bedeutete eine Erweiterung des Gesichtsfeldes. Als Fischereibiologe war er bei Schiemenz durch die beste binnenfischereiliche Schule gegangen. Als Oberfischmeister hatte er praktischen Einblick in die Fischereigesetzgebung und in die Massnahmen zur Förderung insbesondere der Betriebe der Binnen- und Küstenfischerei erhalten. Seine weitere Tätigkeit in Königsberg führte ihn zur Beschäftigung mit der Fischzucht, der Binnenfischerei in Seen, aber auch im Haff und in der Ostsee. Er war einer der wenigen Fischereiforscher, dem die Probleme der Binnenfischerei ebenso bekannt waren wie die der Seefischerei, und der sowohl Limnologe wie Fischereibiologe war.

Ein Bindeglied zwischen der marinen und limnischen Fischereibiologie stellten für ihn vor allem die Salmoniden-Untersuchungen dar. Der Lachs war ein sehr wichtiges Fangobjekt der ostpreussischen Fischerei. Diese Arbeiten insbesondere brachten ihn in Verbindung mit der Deutschen wissenschaftlichen Kommission für Meeresforschung, in die er 1927 aufgenommen wurde. Nach dem Ausscheiden Henkings war er der deutsche Vertreter im Salmon and Trout Committee der Internationalen Meeresforschung.

Schon seine erste Veröffentlichung über den Lachs zeigt eine sehr umfassende Sicht aller Probleme. Er prüfte das Ergebnis der langjährigen Aussetzung von Lachsbrut in deutschen Flüssen und befand sie als wirkungslos. Sein und seiner Schüler systematischer Ausbau der Untersuchungen über Lachswanderungen in der Ostsee auf Grund der Identifizierung der losgerissenen Angelhaken, die die Lachse nicht selten mitführen, ergänzten und berichtigten die bisherigen Vorstellungen in bedeutsamer Weise. Diese Befunde sowie die über die Wachstumsgeschwindigkeit der Salmoniden in den Flüssen und im Meere wollte er bei einer rationellen internationalen Lachswirtschaft berücksichtigt wissen. In Übereinstimmung mit G. Alm erkannte er klar die Notwendigkeit des Zusammengehens der Lachsforschung im Meere und in den Flüssen. Für das deutsche Gebiet erwiesen sich durch seine Untersuchungen

die Aussetzungen von Brut der Meeresforelle als aussichtsreicher als die von Lachsbrut. Er prüfte aber auch systematisch die Möglichkeit der Aussetzung von Brut und Setzlingen anderer Salmoniden im Meere. In seinen Schlussfolgerungen für praktische Massnahmen war er stets vorsichtig und kritisch, angesichts der grossen Verantwortung, die der Fischereibiologe gegenüber dem wirtschaftlich schwachen Berufsstand der selbständigen Fischer trägt. Er hat sich niemals bereitgefunden, Massnahmen zuzustimmen, deren Wirksamkeit nicht klar zu erweisen war, ob es sich nun um Aussetzungen von Brut oder um sogenannte Schonmassnahmen handelte. Gerade in dieser letzten Frage hatten ihn gründliche Studien über die Geschichte der Fischerei sehr skeptisch gemacht: Durch die Jahrhunderte erhebt sich periodisch immer wieder der Ruf nach Schonmassnahmen für Fischereien, die doch auch ohne solche Massnahmen bis zum heutigen Tag ertragreich geblieben sind.

1936 wurde Willer als Oberregierungsrat ins Reichsernährungsministerium berufen. Hier sah er seine wichtigste Aufgabe darin, der Forschung auf dem Gebiete der Fischerei ein geeignetes Fundament zu geben. Dafür schuf er die Reichsanstalt für Fischerei, die nach und nach eine grosse Anzahl bisher isolierter Institute und Forschungsstellen in sich aufnahm. Die Reichsanstalt trug durchaus den Stempel von Willers wissenschaftlicher Persönlichkeit. Er erkannte klar den Mangel jeder isolierten Forschung, die den Blick auf ein mehr oder weniger kleines Teilgebiet des grossen Problemkomplexes Fischerei einengte. So wuchs in ihm die Konzeption der "Fischereiwissenschaft" heran, die das Gesamtgebiet umfasste. Zu ihr gehörte die Erforschung des Biotops der Fische, von den geographischen und hydrographischen Verhältnissen über ihren belebten Lebensraum zu den Beziehungen der Fische zu ihren Nährtieren, Feinden und Parasiten; das gesamte Leben der Fische; weiter aber ihr Fang, ihre Verwertung, ihr Absatz einschliesslich der wirtschaftlichen und rechtlichen Verhältnisse der Fischerei. Es gehörte freilich ein Mann von dem Format Willers dazu, dies Gebiet zu übersehen. Auch gab es für ihn natürlich keine grundsätzliche Trennung der See- und Binnenfischerei. Im Rahmen der Reichsanstalt erwuchs z. B. das längst geforderte deutsche "Institut für Ostseefischerei" in Swinemünde. Willer gründete das Institut für Walforschung und übernahm von der Biologischen Anstalt die Abteilung für Muschelforschung im Sylter Wattenmeer, er überführte die fischereibiologische Abteilung des "Hamburgischen Zoologischen Staatsinstituts" als "Institut für Seefischerei" in die Reichsanstalt, ebenso die in Hamburg und Bremerhaven bestehenden,

im wesentlichen technologisch arbeitenden Institute als "Institut für Fischverarbeitung" und "Institut für Fischverwertung". Reiche Möglichkeiten für Austausch und gegenseitige Anregung und Beratung zwischen den Forschern auf verschiedensten Gebieten war in der Reichsanstalt geboten.

Nicht vergessen werden darf Willers Mitarbeit an dem deutschen Walfanggesetz, das die Möglichkeit einer wirksamen Forschung an Bord der Fabrikschiffe und Fangboote eröffnete, und seine Tätigkeit als deutscher Delegierter auf den Londoner Fischereikonferenzen von 1936/37, die in die Zeit seiner Tätigkeit beim Ernährungsministerium fielen.

Er setzte aber dieser Tätigkeit ein Ende, sobald er die Voraussetzungen für eine universelle Fischereiforschung in seinem Sinne gesichert sah, und wurde Direktor der Reichsanstalt für Fischerei, immer bestrebt, dem jungen Gebilde nun auch seinen Geist einzuhauchen. Aber der 2. Weltkrieg und sein verhängnisvolles Ende zerstörten die hoffnungsvollen Anfänge bis auf kleine Reste. In diesen Resten allerdings, der heutigen Bundesforschungsanstalt für Fischerei, zeigte sich die Lebenskraft des Willerschen Gedankens. Der Neuaufbau ist im Werden.

Auch Willer persönlich schuf sich nach dem Zusammenbruch ein neues Tätigkeitsfeld. 1947 siedelte er nach Hamburg über, erhielt dort einen ordentlichen Lehrstuhl für Fischereiwissenschaft (dem einzigen an deutschen Universitäten), gründete trotz aller Schwierigkeiten der Zeit das Institut für Fischereiwissenschaft und begann aufs Neue eine weitgespannte Tätigkeit. Hier kam er auch in unmittelbare Berührung mit den Problemen der Grossen Hochseefischerei. In seiner Arbeit über die Nutzfischzonen der nordischen Meere ist ein erster Niederschlag der Auseinandersetzung mit demselben zu sehen. Ein neuer Kreis von Schülern hatte sich bereits wieder um ihn gesammelt, als seinem Leben ein Ziel gesetzt wurde. Die zahlreichen Anregungen, die von ihm ausgegangen sind, sind auch in der Meeresforschung nicht ohne Wirkung geblieben.

A. Bückmann.

Water Transmission of Polythene Bottles.

By

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Polythene bottles have recently been widely adopted for storing sea-water samples for analysis. They have many advantages over glass bottles of similar capacity, being lighter, practically indestructible, and readily labelled with wax pencil. There have, however, been reports that sea water stored in such bottles increased in salinity with time. The present work was undertaken to determine quantitatively the errors which could be caused by the permeability of the walls of the bottles to water vapour.

All the bottles used in this work have been of the light thin-walled type fitted with screw caps. This is the type at present widely used for sea-water samples, and is made by blowing the molten plastic into a mould. Some of the bottles used had caps with a conical seating, while others had flat seating and rubber or polythene washers. In both types of cap it was found that providing the neck of the bottle was smooth and free from moulding "flash", it was quite possible to obtain a leak-proof seal.

In the first series of experiments three bottles of similar design by three different manufacturers were tested. A known volume of distilled water was sealed in each bottle, which was then carefully dried externally and weighed. The bottles were then placed in a desiccated container for 24 hours, after which the loss in weight was determined. This was repeated until the loss in weight in each 24 hours was constant. The results for a typical bottle are shown in Figure 1. It will be seen that after an initial period in which the loss in weight is greater than average, the rate reaches a steady value, in this case 7.5 mg. per day.

Further tests were made with a single bottle at various temperatures, the whole bottle and desiccator being immersed in a thermostat. The rate of water loss increased with increase of temperature, as shown in Table 1.

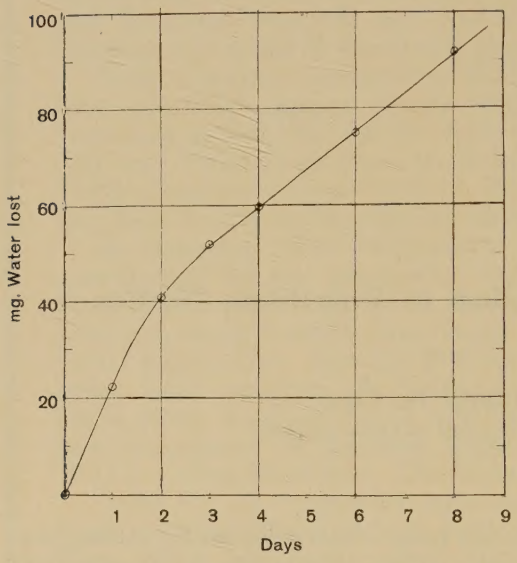

Figure 1. Showing the loss in weight of water from a typical seated bottle.

Table 1.

Temperature of test °C.	Rate of loss of water
20	7.8 mg./day
25	8.4 mg./day
30	9.4 mg./day
35	10.2 mg./day

Table 2.

Bottles with 100 % humidity inside, at 20°C.

Outside humidity %	Loss in weight
0	7.8 mg./day
33	4.6 mg./day
52	3.8 mg./day
90	0.2 mg./day

The effect of varying the humidity of the ambient atmosphere was next investigated. Bottles were stored in hygrostats at various relative humidities. The results were difficult to assess as serious errors can arise from transferring the bottle to the desiccated balance case for weighing, but evidence was obtained that the rate of loss was approximately proportional to the humidity gradient, as shown in Table 2.

These results are in approximate agreement with those quoted by Imperial Chemical Industries (1) in this respect. Other workers (2), however, have stated that there is a complicated relationship between humidity gradient and apparent permeability, and that this is affected by surface conditions.

The ability to transmit water vapour is a characteristic of all plastics. Polythene has a higher resistance to water than any plastic commercially available, but it is known that transmission is appreciable in thin films, and quantitative details have been published (1, 2, 3). If it is assumed that water transmission is proportional to the difference in vapour pressure between the surfaces and inversely proportional to the thickness, then it is subject to the same laws as the transmission of heat through a body. Thus it is stated in the literature (1,4) that the thermal conductivity of polythene is 0.0007 cals./cm.^{2}/cm./°C./sec. while the water "conductivity" is 0.64×10^{-12} g./cm.^{2}/cm./mm.Hg/sec. Let us suppose we find

by experiment that a bottle containing water at a temperature T°C. and surrounded by water at temperature (T—A)°C. loses B calories per second. This bottle can be considered equal to $\frac{B}{A \times 0.0007}$ cm.^{2} of surface 1 cm. thick. This then will transmit $\frac{B}{A \times 0.0007} \times \frac{0.64}{10^{12}} \times 17.6$ g. water per second at 17.6 mm. vapour pressure (at 20°C.)

$$\text{or } \frac{0.58\ B}{A} \text{ mg. water per day.}$$

This factor affords a simple means of computing the water loss to be expected from any particular bottle. The bottle is filled with hot water and equipped with a thermometer and stirrer, and immersed to the neck in a thermostat bath of large capacity, and the rate of loss of heat determined. The water transmission can then be calculated.

These calculations have been made for the three bottles initially tested, with the results shown in Table 3.

Table 3.

	Actual water loss at 20° C.	Calculated loss at 20° C.
Bottle A	5.4 mg./day	0.8 mg./day
Bottle B	8.4 mg./day	1.3 mg./day
Bottle C	8.0 mg./day	1.6 mg./day

Thus in each case the transmission actually measured is considerably larger than the published data would suggest. Tests with three similar bottles by the same manufacturers with various types of closure gave identical transmissions, so it seems most unlikely that these high figures are the result of stopper leakage.

The published figures for water transmission are all measured on thin foil, manufactured by rolling or by extrusion, while the bottles are blown in a mould. Also no details are available of the exact grade of polythene used for the bottles, and it seems possible that various grades, which have very different molecular weights, may differ considerably in resistance to water. No information on this point has been published.

The limit of accuracy obtainable by normal methods in the determination of the salinity of sea water is ± 0.002 ‰. In most routine work it is considered adequate to determine salinity to ± 0.01 ‰. If a polythene bottle contains 100 ml. of sea water with a salinity of 35.000 ‰ then a loss of 3 mg. of water will raise the salinity to 35.001 ‰. Thus on the figures given above if such a bottle were stored at 20°C. and 40 % relative humidity, the salinity could rise from 35.00 ‰ to 35.01 ‰ in three or four days, while at elevated temperatures the error could be greater. A sample stored for a month in a ship's hold could easily be 0.1 ‰ over strength.

From these results it is clear that blown polythene bottles should not be used for storing salinity samples for any considerable time, unless perhaps the results required are only approximate. The rate of water

loss can be reduced by increasing the wall thickness of the bottle, but to reach a stage where the error can reasonably be tolerated a tenfold increase would be needed. This would make the plastic bottle as heavy as an equivalent glass one, and the greatest advantage of the polythene would be lost. Such a bottle would also be very expensive.

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3) C. J. Frosch. Modern Plastics, Nov. 1944, 51-2, 72-4.
4) R. E. Wright. Ind. Eng. Chem., 1950, **42**, 123.
See also "Handbook of Plastics". D. Van Nostrand Co., 1949.

Simplification de la Table de Titration de M. Knudsen pour la Détermination de la Chlorinité de l'Eau de Mer.

Par

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LA Table de Titration de M. Knudsen (2ème partie de *Hydrographical Tables*, 1901[1]), pp. 23—34) a été établie pour donner, dans l'interprétation des résultats des titrations, une précision au plus égale à 0·01 ‰ Cl.

Si l'analyse est faite avec une précision supérieure à 0·01 ‰, et si l'on veut que l'erreur résultant de l'emploi de la table pour passer de la lecture a[2]) à la chlorinité Cl reste négligeable à cette précision, il suffira de calculer k à la 3ème décimale. Ce calcul impliquerait:—

1° que la correction de calibre de la burette, qui doit être incorporée à a, soit exprimée avec 3 décimales;

2° que α soit exprimé avec 3 décimales.

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[1]) Reprinted by Tutein & Koch, Copenhagen, 1953.

[2]) Nous rappelons la signification des différents symboles figurant dans cet article tels qu'ils sont définis dans *Hydrographical Tables* de M. Knudsen pp. III—V:—

N = chlorinité (‰) de l'eau normale.

Cl = chlorinité (‰) de l'échantillon d'eau de mer.

A = lecture à la burette, correspondant à une titration d'eau normale.

a = lecture à la burette, correspondant à une titration de l'échantillon.

$\alpha = N - A$.

$k = Cl - a$.

$\sigma_0 = (s_0 - 1)\,1000$, s_0 étant la densité de l'eau de mer à 0°C., par rapport à l'eau distillée à 4°C.

$\varrho_{17.5}$ $\left(S^{17.5}_{17.5} - 1\right)1000$, $S^{17.5}_{17.5}$ étant la densité de l'eau de mer à 17·5°C., par rapport à l'eau distillée à la même température.

$\varrho'_{17.5}$ = même signification, mais concernant l'eau normale.

Par mesure de simplification, nous représentons, dans cet article, par ϱ et ϱ', respectivement $\varrho_{17.5}$ et $\varrho'_{17.5}$.

Le calcul de k à l'aide de la table existante imposerait, alors, une double interpolation, par rapport à a et α, peu commode, par la disposition même de la table.

Une refonte de cette table nous a donc paru utile. La nouvelle table devrait pouvoir donner k avec 3 décimales pour toutes les valeurs intéressantes de a échelonnées de 0·1 en 0·1 et celles de α de 0·001 en 0·001. Son calcul est possible, mais laborieux, à partir de la table existante. Il peut, d'autre part, entraîner de légères erreurs, de l'ordre de quelques unités de la 3ème décimale, sourtout au voisinage du maximum de k.

H. H. F. Meyer (1932), chargé de l'analyse des échantillons rapportés par le "Meteor", a entrepris ce calcul pour les valeurs de α comprises entre —0·040 et +0·040 mais, dans son compte rendu (1932), il ne publie que la partie correspondant à $\alpha = +0{\cdot}014$ (Table 73, p. 282).

Le calcul direct, à partir des formules de Knudsen,

$$\begin{cases} k = (a+k)\left(R - \dfrac{\varrho}{1000}\right)(1-R) \\ R \quad \dfrac{\varrho'}{1000} + \dfrac{\alpha}{N-\alpha}\left(1 + \dfrac{\varrho'}{1000}\right) \end{cases}$$

serait encore plus laborieux.

Nous avons pu simplifier le problème, en limitant les calculs au cas particulier $\alpha = 0$ et en ramenant, par un artifice de calcul, tous les autres cas à ce cas particulier.

Soient les valeurs a, A, et α, correspondant à une titration.

On a:— $\quad N = A + \alpha$
et l'on pose:— $\quad a = A + \beta.$

Choisissons une nouvelle unité de volume telle que le volume correspondant à la lecture A, exprimé à l'aide de cette unité, ait précisément pour valeur N. Soit u le rapport de la nouvelle unité à l'ancienne. On a:—

$$\frac{A}{N} = u.$$

La nouvelle valeur du volume correspondant à la lecture a est:—

$$a_c = \frac{a}{u} = \frac{A+\beta}{u} = N + \frac{\beta}{u} = N + \beta\left(1 + \frac{\alpha}{A}\right) = A + \alpha + \beta + \frac{\alpha\beta}{A}$$

$$a_c = a + \alpha + \frac{\alpha\beta}{A} \qquad (1)$$

Il suffit, donc, d'élaborer une table pour la seule valeur $\alpha = 0$, et d'y entrer avec la valeur corrigée a_c (*a corrigée*).

Calcul de la table.

Dans le cas particulier où nous nous sommes placés ($A = N$; $\alpha = 0$), les volumes de la solution de nitrate d'argent nécessaires pour précipiter la totalité des ions halogènes contenus dans des volumes égaux d'eau

normale et d'un échantillon d'eau de mer à analyser sont, respectivement, N et a_c, et l'on a:—

$$\frac{a_c}{N} = \frac{Cl\ s}{N\ s'} \text{ ou } Cl = a_c \frac{s'}{s}$$

s étant la densité de l'échantillon et s' celle de l'eau normale, à la température de l'expérience. En prenant cette température égale à 17·5°C., l'équation ci-dessus devient:—

$$Cl = a_c \frac{1 + 10^{-3} \varrho'}{1 + 10^{-3} \varrho}$$

et

$$k = Cl - a_c = a_c\, 10^{-3} \frac{\varrho' - \varrho}{1 + 10^{-3} \varrho}$$

$$k = a_c\, 10^{-3} \frac{26{,}729 - \varrho}{1 + 10^{-3} \varrho} \qquad (2)$$

ϱ' a été calculé pour $Cl = N = 19{\cdot}37\ ^0/_{00}$, à l'aide des deux formules de K n u d s e n:—

$$\begin{cases} \sigma_0 = -0{\cdot}069 + 1{\cdot}4708\ Cl - 0{\cdot}001570\ Cl^2 + 0{\cdot}0000398\ Cl^3 \\ \varrho = (0{\cdot}1245 + \sigma_0 - 0{\cdot}0595\ \sigma_0 + 0{\cdot}000155\ \sigma_0^2)\ 1{\cdot}00129 \end{cases} \qquad (3)$$

Nous avons procédé au calcul de k par la formule (2), de la façon suivante:—

En première approximation, nous sommes partis des valeurs de k données dans la table de titration de K n u d s e n à la colonne $\alpha = 0$, et, par interpolation ou extrapolation linéaires, nous avons dressé un tableau de ces valeurs, puis, de celles de Cl, exprimées avec 3 décimales, pour toutes les valeurs de a de 0·1 en 0·1, comprises entre 0·0 et 23·9. L'extrapolation a été nécessaire de 0·0 à 0·2, puis, de 23·1 à 23·9. Ensuite, à l'aide de la première partie de *Hydrographical Tables* (1901, pp. 1—22), à chaque valeur de Cl du tableau, nous avons fait correspondre une valeur ϱ. Nous avons ainsi obtenu un tableau de correspondance entre les valeurs de a et de ϱ, qui nous a permis de reprendre le calcul définitif de k par la formule (2), dans laquelle $a_c = a$. Pour les valeurs de a de 0·0 à 0·9 et de 23·2 à 23·9, ϱ a été calculé à partir des formules (3).

Le calcul de k par la formule (2) a été effectué avec 4 décimales et les valeurs définitives ont été arrondies à 3 décimales.

La différence entre les valeurs ainsi calculées de k et celles qui avaient été prises en première approximation, et qui ont servi au calcul de ϱ, a été au plus égale à 2×10^{-3}, sauf au voisinage du maximum de k (a de 9·4 à 9·7), où elle a atteint 4×10^{-3}. Au voisinage de ce maximum, la disposition de la table de K n u d s e n rend, en fait, difficile une interpolation précise.

Désignons par k_1 les valeurs de k prises en première approximation, et par k_2 celles données par le calcul. Et soient, respectivement, dk_1 et dk_2 les erreurs faites sur k_1 et k_2. On peut écrire:—

$$dk_1 - dk_2 = k_2 - k_1 \leqslant 4 \times 10^{-3}.$$

L'erreur dk_1 sur Cl entraîne sur ϱ une erreur $d\varrho$, qui entraîne à son tour l'erreur dk_2 sur la valeur définitive de k.

En différentiant les formules (2) et (3), on a:—

$$d\varrho = 1 \cdot 5 \, d\mathrm{Cl} = 1 \cdot 5 \, dk_1$$
$$dk_2 = -a_c \, 10^{-3} \, d\varrho = -1 \cdot 5 \times 10^{-3} \, a_c dk_1.$$

a_c étant toujours plus petit que 24, on peut écrire:—

$$| dk_2 | < 1 \cdot 5 \times 10^{-3} \times 24 dk_1 < 0 \cdot 04 \, dk_1.$$

Dans l'expression $dk_1 - dk_2$, on peut donc négliger dk_2 devant dk_1 et écrire $dk_1 \leqslant 4 \times 10^{-3}$, ce qui entraîne $dk_2 < 2 \times 10^{-4}$, donc négligeable.

De même, il est aisé de démontrer que l'erreur pouvant résulter du léger écart suspectible d'exister, pour un échantillon d'eau de mer, entre sa densité réelle et celle donnée par *Hydrographical Tables* en fonction de Cl, est également négligeable.

Nous pouvons, donc, considérer les valeurs définitives de k, figurant dans notre table, comme exactes à la précision de la 3ème décimale.

La nouvelle table que nous proposons, qui n'est, en fait, qu'une simplification de la table de titration de K n u d s e n, figure ci-dessous.

Table de Titration donnant $k \cdot 10^3$ en fonction de a_c.

	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	D
0	0	3	5	8	10	13	16	18	20	23	3
1	25	28	30	32	35	37	39	41	43	45	2
2	48	50	52	54	56	58	60	62	63	65	2
3	67	69	71	72	74	76	77	79	81	82	2
4	84	85	87	88	90	91	92	94	95	96	1
5	98	99	100	101	102	103	105	106	107	108	1
6	109	110	110	111	112	113	114	115	115	116	1
7	117	118	118	119	119	120	121	121	122	122	1
8	122	123	123	124	124	124	125	125	125	125	0
9	125	125	126	126	126	126	126	126	126	126	0
10	126	125	125	125	125	125	124	124	124	123	0
11	123	123	122	122	121	121	120	120	119	119	—1
12	118	117	117	116	115	114	114	113	112	111	—1
13	110	109	108	107	106	105	104	103	102	101	—1
14	100	99	97	96	95	94	92	91	90	88	—1
15	87	85	84	82	81	79	78	76	75	73	—2
16	71	70	68	66	64	63	61	59	57	55	—2
17	53	51	49	47	45	43	41	39	37	35	—2
18	32	30	28	26	23	21	19	16	14	12	—2
19	9	7	4	2	—1	—3	—6	—9	—11	—14	—3
20	—17	—19	—22	—25	—28	—30	—33	—36	—39	—42	—3
21	—45	—48	—51	—54	—57	—60	—63	—66	—69	—72	—3
22	—76	—79	—82	—85	—89	—92	—95	—99	—102	—106	—3
23	—109	—112	—116	—119	—123	—127	—130	—134	—137	—141	—4

Disposition et usage de la table.

La table donne, directement, la valeur de k pour les valeurs de a_c limitées à la première décimale. Les différences tabulaires sont données dans la dernière colonne, D, et rendent immédiates les interpolations pour la 2ème décimale de a_c. Un trait épais sépare, enfin, les groupes des valeurs positives et négatives de k et de D.

A partir de a, A, et α, ces valeurs étant supposées corrigées de l'erreur de calibre de la burette, on calcule avec 3 décimales:—

$$a_c \quad a + \alpha + \frac{\alpha\beta}{A}.$$

Suivant la précision des mesures, a et A, avant l'addition de la correction de calibre, auront ou non une 3ème décimale. Généralement, les titrations sont faites à la précision de 0·005 ‰ Cl, et la 3ème décimale est, alors, 0 ou 5. Par contre, α devra être exprimé avec 3 décimales, ainsi que la correction de calibre de la burette.

A cette valeur a_c, on ajoute le nombre k correspondant, tiré de la table, et l'on a:—

$$\mathrm{Cl} = a_c + k.$$

On arrondit, enfin, la valeur trouvée pour Cl, conformément à la précision des mesures.

Ex.: $a_c = 19{\cdot}261$; $k.10^3 = +4 - 3\times0{\cdot}6 = +2$; Cl = 19·263. On prendra Cl = 19·265 ‰ si la précision des mesures est de ±0·005 et 19·26 ‰ si cette précision est de ±0·01.

Pour des échantillons océaniques à salure voisine de la normale, β est petit en valeur absolue. On peut, alors, rendre négligeable le terme $\frac{\alpha\beta}{A}$, en choisissant le titre de la solution de nitrate d'argent de manière que α, en valeur absolue, soit suffisamment petit.

On retrouve, ainsi, la condition imposée par la table de K n u d s e n, qui n'est utilisable que pour $|\alpha| \leqslant 0{\cdot}15$. Toutefois, cette condition n'est, ici, nullement impérative, et l'un des avantages de la nouvelle table est, précisément, de libérer de cette sujétion. *L'interprétation de l'analyse est toujours possible, avec la même précision, quel que soit le titre de la solution de nitrate d'argent utilisée.*

Une feuille d'analyses pourrait être disposée de la façon suivante:—

1	2	3	4	5	6	7	8	9	10
Heure	Température	No. de l'échantillon	a	$a+\alpha$	β	$\frac{\alpha\beta}{A}$	a_c	Cl	Observations

Les valeurs figurant aux colonnes 4 et 5 sont supposées corrigées de l'erreur de calibre de la burette.

Notons que $\beta = a + \alpha - N$. β peut donc être calculé en retranchant N du nombre figurant à la colonne 5.

A chaque titration d'eau normale, on calcule α et $\frac{\alpha}{A}$, et on inscrit ces deux nombres dans la colonne 10. Dans les cas courants, eau océanique, titre convenable de la solution de nitrate d'argent rendant α petit en valeur absolue, on peut se contenter, pour le calcul de $\frac{\alpha}{A}$, quand ce calcul est nécessaire, de prendre A = 20.

Lorsque le terme $\frac{\alpha\beta}{A}$ est négligeable, les colonnes 6 à 8 sont sans objet ($a_c = a + \alpha$).

Limites d'utilisation de la table.

Les limites d'utilisation de la nouvelle table, pour des valeurs de N différentes de 19·37 ‰ et de la température θ différentes de 17·5°C. (valeurs pour lesquelles elle a été calculée), restent celles définies par M. Knudsen (1902, p. 163), suivant les deux formules:—

$$\begin{cases} \frac{dk}{dN} = 0{\cdot}04 \\ \frac{dk}{d\theta} = \frac{0{\cdot}001}{3} \end{cases} \qquad (4)$$

Formule.

Lors du calcul de la nouvelle table, le paramètre a_c variant en progression arithmétique, les différences secondes de k ont été trouvées sensiblement constantes. k peut donc être correctement représenté, pour l'ensemble des valeurs étudiées de a_c, par une fonction du 2ème degré en a_c, nulle pour 0 et 19·37 et présentant un maximum pour $a_c = \frac{19{\cdot}37}{2}$.

La formule suivante:—

$$k \,.\, 10^3 = 1{\cdot}337\, a_c (19{\cdot}37 - a_c) - 25{\cdot}90\, a_c - 1{\cdot}337\, a_c^2 \qquad (5)$$

permet de calculer k avec une précision de 2×10^{-3} pour les valeurs de a_c comprises entre 0 et 22.

Le coefficient de a_c^2 a été déterminé par la méthode des moindres carrés.

Les écarts entre les valeurs obtenues par cette formule et celles données dans notre table, sont représentés, en fonction de a_c, Figure 1.

Application. Titrage des échantillons d'eau de mer pour lesquels la lecture *a* sortirait de l'échelle de graduation de la burette.

Par un choix convenable du titre de la solution de nitrate d'argent, on peut allonger sensiblement l'intervalle d'utilisation de la burette

classique de K n u d s e n, dans un sens ou dans l'autre. Le titre de la solution de nitrate d'argent doit, toutefois, être tel que la lecture A correspondant à l'eau normale reste dans les limites de l'échelle de graduation.

Supposons une burette graduée de 17 à 21. Avec une solution de nitrate d'argent de faible concentration telle que A = 20·5, on peut titrer des échantillons jusqu'à une chlorinité de 16·2 $^0/_{00}$.

Avec une solution de nitrate d'argent de forte concentration telle que A = 17·5, on peut aller jusqu'à Cl = 23·1 $^0/_{00}$.

En disposant d'une gamme convenable de réactifs, l'intervalle d'utilisation de la burette s'étendra donc de 16 à 23 $^0/_{00}$, pratiquement, pour toutes les *eaux de mer* proprement dites.

Bien entendu, dans ces cas, il est nécessaire de calculer le terme $\frac{\alpha\beta}{A}$ avec précision.

Le titre d'une solution de nitrate d'argent pourra être caractérisé par la valeur A de la lecture que cette solution donne, en moyenne, avec l'eau normale.

Soit t_A ce titre, que nous définissons comme la masse du sel d'argent contenu dans un litre *de la solution,* à la température du laboratoire, et t_N celui correspondant à la lecture N ($\alpha = 0$). On a:—

$$t_A \quad t_N \frac{N}{A} \tag{6}$$

Voici la valeur de t_N, à différentes températures, pour les pipettes et burettes classiques (volume de la pipette, 15 ml.; unité de graduation de la burette, 2 ml.):—

Température:	15	17·5	20	25	°C.	
t_N	36·87	36·85	36·83	36·78	g./l.	*(de la solution).*

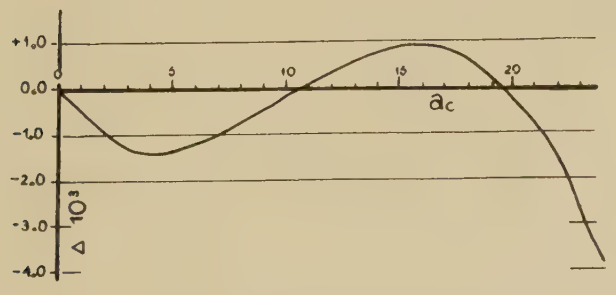

Figure 1. Courbe donnant, en fonction de a_c, la différence Δ entre les valeurs de k obtenues, d'une part, à l'aide de la formule (5) et, d'autre part, à l'aide de la table.
$(\Delta = k_{calc.} - k_{table})$.

Dans les exemples précédents, et pour 17·5°C.,

à A = 20·5, correspond le titre $t_{20\cdot5} = 36\cdot85 \frac{19\cdot37}{20\cdot5} = 34\cdot82$

à A = 17·5, correspond le titre $t_{17\cdot5} = 36\cdot85 \frac{19\cdot37}{17\cdot5} = 40\cdot79.$

Références.

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1902 — Knudsen, M., Forch, C., Sørensen, S. P. L. "Bericht über die chemische und physikalische Untersuchung des Seewassers und die Aufstellung der neuen Hydrographischen Tabellen." Wiss. Meeresunters., Abt. Kiel, N. F., 6.
1932 — Wüst, G., Böhnecke, G., Meyer, H. H. F. "Ozeanographische Methoden und Instrumente." Wiss. Ergebn. Deutsch. Atlant. Exped. "Meteor", 1925—1927, V, 2, 281—282.

On Organic Production in the Oceans.

By

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1. Introduction.

In a previous article (Steemann Nielsen, 1952), a method for measuring the organic production in the sea by means of radio-active carbon (^{14}C) was described. Two slightly different modifications for the measurement of production of matter in a column beneath a unit surface of the sea were given. In the first modification, samples of water are taken from various depths in the photic zone and transferred to bottles with glass stoppers. After addition of ^{14}C in the form of a solution of sodium bicarbonate, the bottles are suspended at the depth from which the samples were taken, and left there for a definite time, for instance, from noon till sunset. After the exposure period, the plankton is filtered off and the amount of ^{14}C assimilated is determined by measuring the β-radiation. To calculate the total carbon assimilated, it is necessary to multiply the amount of ^{14}C found by a factor corresponding to the ratio between $CO_{2\ (total)}$ and $^{14}CO_2$ in the water. As, however, ^{14}C is not assimilated at quite the same rate as ^{12}C, a correction for the isotope effect must be made.

In the other modification of the method for measuring production, the bottles containing water samples from different depths are placed in a water-bath which is illuminated by a definite light intensity. The penetration of light in the sea has to be determined at the time of collection. The production of matter beneath a unit surface is calculated by means of a formula derived by comparing the results from stations at which observations were made simultaneously by the two modifications of the method.

Details of the method can be found in the above-mentioned paper and are also treated at length in the final report of the "Galathea" Expedition. It is hoped that the latter will be published in 1954.

In the present paper some of the main results are given from measurements of rates of organic production obtained on the "Galathea" Expedition. In the 1952 article, which was prepared and printed during the expedition, the results from the first transoceanic cruise (Indian Ocean, from Mombassa to Ceylon) were given provisionally. Although the working up of the material from this cruise has now been completed, only the results from the expedition's traverses in the Pacific and Atlantic Oceans will be given here, since these latter sections give a better general picture of the productivity in the subtropical and tropical

parts of the oceans. The transoceanic cruise of the "Galathea" in the Indian Ocean covered an area which, due to the hydrographic conditions — the route of the "Galathea" was to some extent parallel with a divergence — was more productive than most tropical parts of the oceans. Since a similar area was crossed by the "Galathea" in the transoceanic section in the Pacific, it is more convenient to describe oceanic conditions by the sections across the Pacific and the Atlantic.

The stations from the southern part of the Benguela Current are also given, since this is the most productive area investigated by the "Galathea". In this region, where pronounced upwelling occurs of water rich in nutrient salts, a rate of production of organic matter per unit area per day was found, comparable with the productivity in good cornfields on land.

One of the main results of the "Galathea" investigations is that a marked correlation exists between the rate of production and the hydrographic conditions. In the open sea a high productivity is found only in regions with a pronounced movement of water from deeper layers to the surface.

The "age" of the surface water is the most important factor in determining the production of organic matter in the oceans (cf. S v e r d r u p and A l l e n, 1939). Only when a significant part of the surface water is "new" is a considerable rate of production found.

2. The Section from New Zealand to California.

Figure 1 gives the rates of organic production in the section from New Zealand to California. The direction of the route was northwestward to Honolulu. From there the "Galathea" continued straight on to San Francisco. All stations were made between the beginning of March and the beginning of April, with the exception of St. 641, made at the end of January. This neritic station, at the mouth of Hauraki Gulf, New Zealand, and the last station of the section, St. 701, in the coastal water outside San Francisco, are added to give a suitable contrast to the other stations of the section, which are all truly oceanic. The two neritic stations represent coastal areas with a high organic productivity — about 0·6 g. C per square metre per day.

The "Carnegie's" last cruise in 1929, together with the "Dana's" cruise, in 1928—1930, gives valuable information on the hydrography of the area in question (see S v e r d r u p et al., 1942). Between the North and South Equatorial Currents, in the east, there lies the remarkably well developed Equatorial Counter-Current. The "Carnegie" found two regions of divergence in which the ascent of water from medium depths to the surface could be clearly recognized. One of these regions is situated in the South Equatorial Current near the equator and the other on the northern boundary of the Counter-Current. In these regions concentrations of slightly more than 0·4 μg.-atoms P per litre were found at the surface. Net catches of plankton (G r a h a m, 1941) were also rich here.

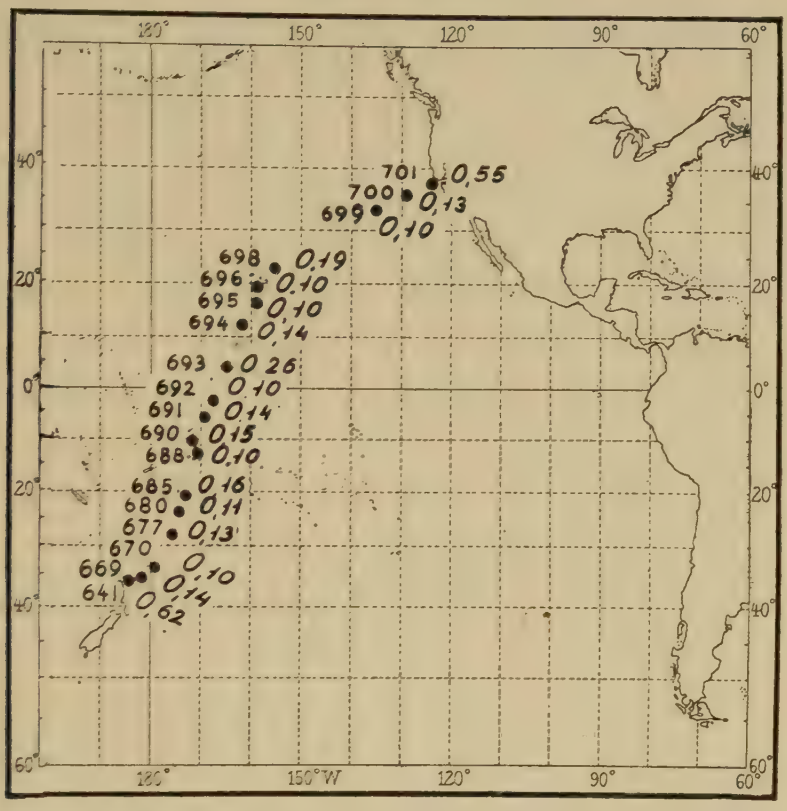

Figure 1. Section from New Zealand to California. Station numbers to the left, organic production (g. C per square metre per day) to the right. A "station" between St. 692 and St. 693 showing a production of about 0·5 g. C is omitted.

The "Galathea's" section is further westward than the "Carnegie's". According to S v e r d r u p et al. (1942, Figure 197) the depth of the discontinuity surface near the equator increases from east to west. This indicates a less pronounced admixture of water from medium depths on the "Galathea" section than on the "Carnegie" section. On the latter, between 8°S. and 3°N., concentrations $\leq$ 0·4 μg.-atom P per litre at the surface were found. On the "Galathea" section such a high phosphorus concentration was found only at St. 192 (2°47′S.). A concentration of 0·2 μg.-atom P per litre was, however, found at the surface at all stations between 6°S. and 4°N.

The rate of organic production was fairly uniform at the "Galathea's" oceanic stations on this section. With the exception of the stations near the divergences caused by the Equatorial Counter-Current, the rate varied only between 0·10 and 0·19 g. C per square metre per day.

Only two stations were made by the "Galathea" in the region influenced by the divergences produced by the Counter-Current. The

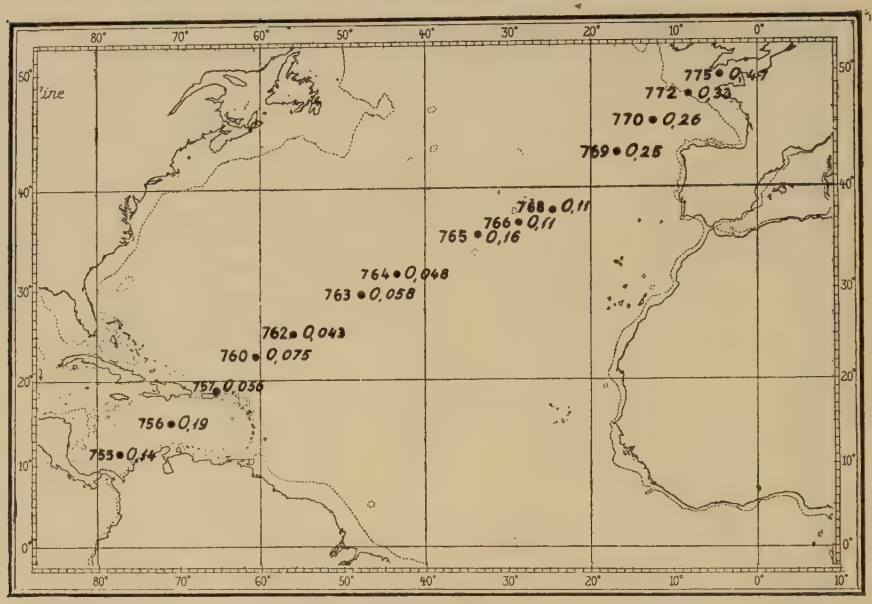

Figure 2. Section from Panama to the English Channel. Station numbers to the left, organic production (g. C per square metre per day) to the right.

rates of production were 0·26 and 0·5 g. C respectively. The last value is unfortunately not very reliable. Only the productivity of the surface water was measured, since unfortunate circumstances made it impossible to carry out intensive investigations in this interesting locality.

The thickness of the photosynthetic layer at the oceanic stations of the section was found to vary mostly between 95 and 120 m., with the exception of the stations in or near the Counter-Current, where a depth between 78 and 85 m. was found. The layer was 77 m. deep at St. 700. The latter station is in the approaches to the Californian coast.

The oceanic surface water encountered on the section in question must be characterized as of medium "age", excepting in the region near the divergences caused by the Counter-Current, where the surface water must be regarded as fairly "new" (for a discussion of the "age" of the surface water, see Section 5). An organic productivity of 0·10—0·19 g. C per square metre per day is thus characteristic of subtropical and tropical regions having surface water of medium "age".

3. The Section from Panama to the English Channel.

Figure 2 shows the rates of organic production on the section from Panama to the English Channel. The section was run during May and June 1952. The first two stations — 755 and 756 — are situated in the southern part of the Caribbean Sea, St. 757 and St. 760 in the Antilles Current, which is a continuation of the North Equatorial Current to the westward. Stations 762—764 are in the Sargasso Sea,

stations 765—772 in the North Atlantic Current, the last of the stations mentioned being situated on the continental slope. St. 775 lies at the mouth of the English Channel.

The hydrographic conditions of the North Atlantic are well known; an excellent survey is given by S v e r d r u p et al. (1942). The surface water in the Caribbean Sea has its origin in the North Equatorial Current, which, at its western end, carries fairly "old" surface water. The main eddies in the Caribbean Sea, affecting vertical mixing of the water masses, are situated more to the north. In the southern part of this region oceanic productivity is therefore normal — 0·14—0·19 g. C per square metre per day.

The production of organic matter in the Antilles Current is poor, being only 0·056—0·075 g. C, which accords with the rather old "age" of the surface water.

About the lowest oceanic productivity anywhere found by the "Galathea" — 0·043—0·058 g. C per square metre per day — occurred in the Sargasso Sea. In this big anticyclonic eddy in mid-Atlantic the surface water is "old", and the same water circulates here for a fairly long time. The surface water of the eddy receives contributions from the sides, partly from the western end of the North Equatorial Current (carrying "old" surface water) and partly from the uppermost layers of the Gulf Stream. Owing to the anticyclonic sense of the eddy, which is situated in the northern hemisphere, there is a tendency for the surface water to descend near the centre (see Figure 7 — B ö h n e c k e et al., 1930). This effect is to be seen in the distribution of the nutrient salts below the photosynthetic zone. Concentrations above 0·4 μg.-atoms P per litre are first found several hundred metres below this zone, which, in the Sargasso Sea, reaches down to about 120 m. (see "Dana" stations 3540—3544 — T h o m s e n, 1937). Thus only quite minimal amounts of the nutrient salts are conveyed to this zone by mixing with water from below the photosynthetic zone.

It is therefore readily understandable that the rate of organic production in the Sargasso Sea is low. This sea has long been regarded as a poor region, and the blue water there has been described as an oceanic desert. The paucity of plant production is reflected also in the rate of animal production. The smallest volumes of zooplankton reported by the Danish "Dana" Expedition round the world were found in the Sargasso Sea (see J e s p e r s e n, 1935). The findings of R i l e y, who believes the Sargasso Sea to be a productive area, are discussed in the Appendix, p. 325.

Stations 765—768, in the North Atlantic Current, represent a region of typically subtropical oceanic surface water of medium "age". The rate of organic production varied between 0·11 and 0·16 g. C per square metre per day. As one approaches the European continent, organic productivity increases — probably due to the activity of the eddies found here. At St. 772 the production rate was 0·33 g. C per day.

Finally, a productivity of 0·47 g. C per square metre per day was found at St. 775, in the mouth of the English Channel. If production

occurs here at this rate throughout the months of March to June, the result will be a productivity of the same order of magnitude as was estimated by the Plymouth Laboratory, from the decrease of phosphate from spring to summer (see H a r v e y, 1945, p. 145).

4. The Southern Part of the Benguela Current.

Figure 3 shows the "Galathea's" results in the most productive area visited by the expedition. The southern part of the Benguela Current is known to be one of the most productive areas in the oceans. The

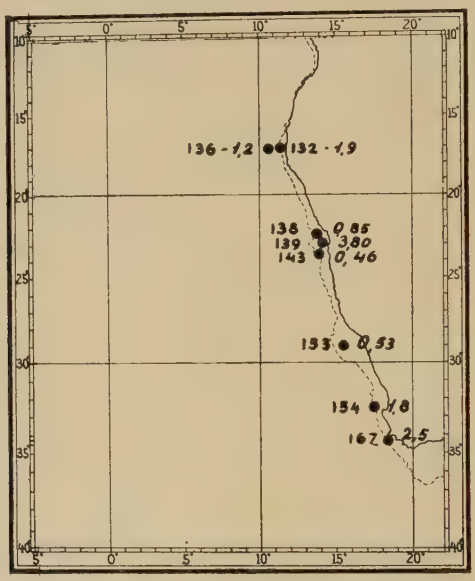

Figure 3. The southern part of the Benguela Current. Station numbers to the left, organic production (g. C per square metre per day) to the right.

current flows along the west coast of South Africa and is particularly conspicuous between the southern extremity of Africa and lat. 17° to 18°S. (S v e r d r u p et al., 1942). Under the influence of the prevailing southerly and south-easterly winds, the surface layers are carried away from the coast, and upwelling of the water from moderate depths takes place in most seasons of the year. These hydrographic conditions give rise to an enormously rich phytoplankton, since the upwelling water is rich in nutrient salts and establishes excellent conditions for plankton production. In the Benguela Current we find typically "new" surface water. In the Pacific, the Peru Current flowing along the west coast of South America presumably gives rise to a production equal to that in the Benguela Current.

According to the "Galathea's" measurements in the current the rate of organic production varied between 0·46 and 2·5 g. C per square metre

per day (in Walvis Bay, 3·8 g. C). We must expect considerable variation, however, in productivity in a locality like the southern part of the Benguela Current, on account, for example, of the shape of the coast, and the weather conditions peculiar to it. No attempt will be made here to discuss the single stations (see page 324).

5. Factors Determining Organic Productivity in the Oceans.

It is now well established (see, e. g., S v e r d r u p et al., 1942) that the factors governing production of phytoplankton in the sea are, in the main, the following:— A) supply of nutrient salts, B) light, C) temperature, and D) grazing by animals. The relative importance of these factors, however, is not so well known.

The investigations made on the "Galathea" Expedition have furnished weighty evidence of the fact that the supply of nutrients — manifested by the "age" of the surface water — is by far the most important factor governing the production of phytoplankton in the tropical and subtropical parts of the oceans.

A) Supply of nutrient salts.

It is not necessary to discuss in detail the importance of the nutrient salts. The concentrations of nitrate and especially phosphate — which is more easily determined — in the photosynthetic water layer are often used as an index of productive capacity. Though this index is correct under certain conditions, it is not always so. In areas with pronounced upwelling of water rich in nutrients, the high concentration of these salts found near the surface gives evidence of a high potential productivity. On the other hand, a low concentration of free phosphate in the photosynthetic layer is by no means an indication of the absence of potential productivity in an area. This may mean simply that phosphate is used up as fast as it is conveyed to the photosynthetic layer (disengagement from organic compounds included), or is stored in the cells of the plankton algae present, in which condition it represents a highly potential source for further plant production.

It has been shown by several limnologists (see, for instance, R o d h e, 1948) that freshwater plankton algae — like higher plants — are able to absorb and store large amounts of phosphate in the cells. If no free phosphate is found in the water, it is impossible to decide whether or not there is phosphate available for further organic production. In some localities it is fairly easy to employ hydrographic methods to determine the extent to which nutrient salts are conveyed to the photosynthetic layer from below — as, for example, in the waters between the Baltic and the North Sea (see S t e e m a n n N i e l s e n, 1940). For other reasons, it is not difficult to imagine that, in the Sargasso Sea, the admixture of nutrient salts from below must be very slight. There, just below the photosynthetic zone, only very small concentrations of the nutrient salts are present. An admixture of such water is of only little value. A concentration of 0·2 μg.-atoms P per litre is not found in this area until a depth is reached 200 metres below the photosynthetic zone.

Nutrient salts are supplied not only from below but also by horizontal currents. Nutrients carried up to the surface in one particular place may therefore influence other regions too, if they are connected by horizontal currents.

At the moment, it is impossible to say how long a phosphorus atom carried up into the photosynthetic layer is, on the average, likely to stay there and in how many phytoplankton cycles it may participate before being lost by sinking below the photosynthetic zone. Local variations will certainly occur. It can easily be demonstrated, however, that a particular surface water, rich in nutrients, and therefore capable of high organic productivity, becomes poorer and poorer as it is transported by a horizontal current to regions where no other enrichment of the surface water takes place. The North Equatorial Current in the Atlantic offers a typical example. At the start of this current near the African coast, upwelling of water rich in nutrients takes place. As found by the "Galathea" (data unpublished) organic production is here rich. The western part of this current, the Antilles Current, on the other hand, is characterized by low productivity. The further continuation of the current, the mid-Atlantic eddy (the Sargasso Sea), exhibits still lower productivity. The "age" of the surface water, therefore, is of decisive importance, as was first stressed by S v e r d r u p and A l l e n (1939).

As pointed out above, the investigations of the "Galathea" furnish very strong evidence in support of the importance of the "age" of the surface water in regard to organic productivity in the tropical and subtropical parts of the oceans.

B) Temperature.

Variations in temperature strongly influence the rate of respiration and the rate of photosynthesis, at a high light intensity, in plankton algae as in all other autotrophic plants. This does not necessarily mean, however, that the rate — measured per dry weight — is much lower in the arctic than in the tropics. A higher concentration of the enzymes participating in respiration and photosynthesis may counteract the depressing effect of the low temperature in the arctic. Marine phytoplankton has not been studied in this respect. Several authors — e. g., S p ä r c k (1936) — give examples of cases in which the rate of respiration of a definite animal species is less at the same temperature for individuals which have been collected from a warmer environment than for individuals collected from colder waters. If this occurs with individuals of the same species it is probably still more pronounced when cold- and warm-water species are compared.

The extent to which organic productivity in the sea is directly influenced by temperature is not known. The indirect influence of this factor is perhaps the more important. Low temperature often seems to have a pronounced effect through inhibiting the activity of bacteria. An increase in temperature may possibly, first of all, accelerate the regeneration of the nutrient salts with the result that organic production is also accelerated.

C) Light intensity.

Light intensity is the most important limiting factor in highly productive regions having a rich supply of nutrient salts. It is also limiting in high latitudes during winter, or in regions lacking stability of the water column, e. g., the Antarctic Ocean during spring. However, in tropical and subtropical parts of the oceans, outside localities with a pronounced upwelling of water, light intensity seems to be of little importance as a limiting factor.

Let us consider a tropical or subtropical station at which the depth of the photosynthetic layer is 100 m. If the plankton algae are evenly distributed in the layer — and the light absorption is the same at all depths — we obtain the hypothetical curve shown in Figure 4. This represents the daily relative rates of total photosynthesis at the different depths on a clear day. The maximum rate is found at a depth of about 20 m., where the average of the blue and green part of the light falling on the surface is reduced to nearly one-third. As the rays of the red part of the spectrum are completely absorbed in the upper 5 to 10 m., we may disregard this part of the light. The light intensity being too high near the surface causes a reduction in the rate of photosynthesis.

If the light falling on the water surface is reduced throughout the day to one-third, the rate of photosynthesis at the surface is the same as that taking place at a depth of 24 m. on a clear day. With a decrease of the light intensity to one-third, the photosynthetic rate per unit volume of surface water (g. C/m.^{3}) thus increases by nearly 50 %. However, the photosynthetic layer is now only 76 m. deep. The curve for light intensity one-third is identical with the curve (Figure 4, light intensity $\frac{1}{1}$ at the surface) which would appear if the curve is shifted bodily 24 m. upwards. The rate of total photosynthesis measured per square metre (g. C/m.^{2}/day) is thus about two-thirds of that measured at the light intensity $\frac{1}{1}$ at the surface. By reducing the light intensity at the surface to one-tenth, the curve (Figure 4) has to be moved bodily 50 m. upwards, which reduces the

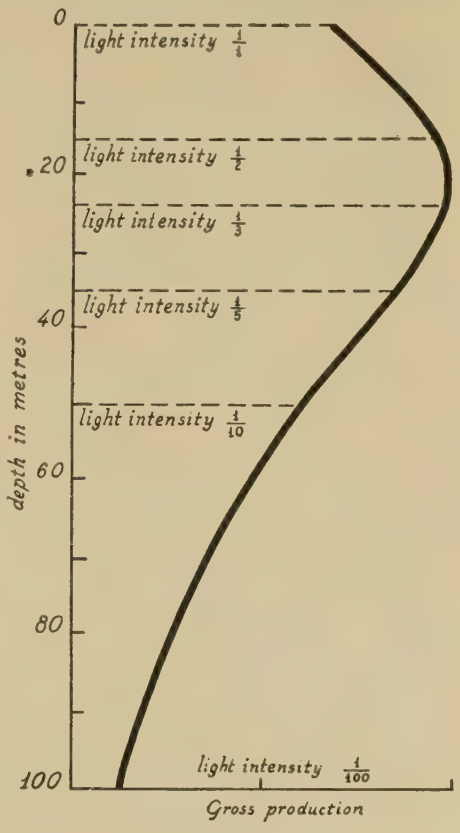

Figure 4.

depth of the photosynthetic layer to 50 m. The rate of total photosynthesis at the surface as g. C per cubic metre per day decreases about 15 %, and the rate as g. C per square metre per day decreases to about 25 % of the rate at light intensity $\frac{1}{1}$ at the surface.

A day with a light intensity of only one-tenth of that on a normally clear day is in fact very dark — one, for example on which rain falls throughout the day. Only in such very dark weather does a slight reduction of the photosynthetic rate occur (per unit volume) at the surface.

The rate of photosynthesis below a unit area is affected somewhat more by the weather conditions, but the rate is seldom reduced by more than 50 %. On extremely dark days only, the rate is reduced by about 75 %.

If other hydrographic conditions are the same throughout the year, no significant variations in organic productivity are presumably to be expected in the tropical parts of the oceans. In the subtropical parts the variations between summer and winter are believed to be fairly small. According to Table 25 in Sverdrup et al. (1942), in the Sargasso Sea at 30°N. the average amount of radiation from sun and sky which reaches the sea surface in the darkest month of the year (December) is about 50 % of the amount in the brightest month (August). According to Figure 4, with the other factors presumed to be the same, the rate of organic production per unit area in the darkest month is about 80 % of the rate in the brightest month.

In Danish waters (56°N.), on bright days during mid-winter, a rate of organic production per unit area of about 20 % of the rate found on bright days during summer may occur — although not in all winters (unpublished studies by the author).

D) Grazing by animals.

The effect of grazing will be discussed in another publication. Various experiments were performed in the "Galathea" to obtain information regarding this factor. Grazing was found to be fairly important.

6. The Amount of Organic Production.

Investigations carried out during the "Galathea" Expedition have shown that the amount of organic production in the tropical and subtropical parts of the oceans is strictly dependent on the hydrographic conditions in the locality. Although experiments were made only once at each oceanic station there is every indication that the results obtained provide a reasonably correct picture of the productivity of the region. It must of course be stressed that this is by no means applicable to temperate and arctic waters and to a certain extent to many tropical and subtropical coastal waters also.

It is possible to distinguish four different classes of oceanic regions according to amount of organic production. These are applicable only to tropical and subtropical parts of the oceans. Graduations between them are of course found.

(i) Regions with a very considerable admixture of "new" water to the photosynthetic zone. "New" water is water rich in nutrient salts originating from medium depth. The daily organic production is from 0·5 to about 3 g. C per square metre. An example of this class is the southern part of the Benguela Current.
(ii) Regions with a fairly steady admixture of "new" water to the photosynthetic zone. The daily organic production is about 0·2—0·5 g. C per square metre. This may be exemplified by the regions in the neighbourhood of the divergences caused by the Equatorial Counter-Currents in the different oceans.
(iii) Areas without a pronounced admixture of nutrient-rich water from below. Some admixture — although of minor importance — may occur, however, through turbulence. The daily organic production is 0·1—0·2 g. C per square metre. By far the largest parts of the tropical and sub-tropical regions of the oceans belong to this category.
(iv) Areas with typically "old" surface water in the photosynthetic zone. This water, originally rich in nutrients, has been transported from a distant region, and the lapse of a long time has resulted in decrease in nutrient content since the water entered the photosynthetic layer. Turbulence is of slight importance only, since nutrient-rich water is present only far below the photosynthetic zone. The rate of organic production is about 0·05 g. C per square metre per day. An example of this is the Sargasso Sea.

Though I am aware that much too little is known about the productivity of the arctic, antarctic, and temperate seas, where seasonal changes are very pronounced, I have nevertheless ventured to estimate the average daily gross production in all seas as about 0·15 g. C assimilated per m^2. According to this, the net production for the whole hydrosphere is about $1{\cdot}5 \times 10^{10}$ tons of carbon per year, which is the same as the most usual estimate for production on land.

7. Depth of the Photosynthetic Layer and Rate of Organic Production.

On the "Galathea" Expedition a high rate of organic production was always found in conjunction with a shallow photosynthetic layer. In Walvis Bay, on the coast of South Africa, where the highest rate of production was recorded — 3·8 g. C assimilated per square metre per day — the photosynthetic layer was only 0·8 m. deep.

The data for 184 "Galathea" stations are presented in Table 1. These reveal a marked negative correlation between the vertical extent of the photosynthetic layer and the rate of organic production. For a depth of 100—120 m. none of the stations has a rate of production above 0·24 g. C. For a depth of 75—99 m. none has a rate above 0·49, the main part showing a rate between 0·11 and 0·24 g. C. For a depth of 50—74 m. none of the stations has a rate of production above 0·99 g. C but about a quarter of the stations in this category show rates between

Table 1.

Correlation between the vertical extent of the photosynthetic layer and the rate of gross production.

Rate of gross production in g. C/m²./day	The vertical extent of the photosynthetic layer in metres				
	0-24	25-49	50-74	75-99	100-120
>1	7	3			
0·50—0·99	6	13	12		
0·25—0·49	6	15	17	9	
0·12—0·24	2	6	15	37	12
0·0 —0·11	2	1		9	12

(The numbers within the table are numbers of stations)

0·50 and 0·99 g. C. For a depth of 25—49 m. a few stations have a rate of production above 1 g. C, but for the most part they are characterized by rates between 0·25 and 0·99 g. C. The stations with the shallowest photosynthetic layer — less than 24 m. — belong essentially to the category with a rate of production above 1 g. C.

It is, however, to be borne in mind that some coastal stations, at which suspended clay and other material result in decreased light penetration, may at the same time be characterized by a thin photosynthetic layer and an insignificant rate of organic production. The stations off the mouth of the Congo River provide typical examples of this kind. But in general a marine area with a shallow photosynthetic layer is very productive. If, on the other hand, the photosynthetic layer is deep, the rate of production is always low.

In the clearest ocean water, as for example the deep-blue waters of the Sargasso Sea, the depth of photosynthetic layer is about 120 m. It is of considerable interest to estimate the rate of production which can be expected theoretically in waters with such a deep photosynthetic layer. This can be done by using the results from experimental plankton work.

During the last few years — see, for instance, B u r l e w (1953) — important work has been done in various countries on the determination of the maximum possible rate of organic production by plankton algae grown in large basins in a pilot plant under natural light conditions. In these experiments light intensity is almost the only limiting factor. All other factors — e. g., the concentration of nutrient salts — are made as optimal as possible. The most successful experiments yield a net production rate of slightly more than 10 g. dry matter per square metre per day. This means a gross production of about 5 g. C per square metre per day — that is about 30 % more than occurs under natural conditions in Walvis Bay.

The depth of the algal suspension in the basins is only a few centimetres. The concentration of the algae — mostly *Chlorella* — is so high that nearly all the light penetrating the surface of the basins is absorbed by the algae. The light absorption in the thin layer of water is without any importance.

If the plankton is distributed with the same concentration at all depths, the penetration of the light can be described with sufficient accuracy by the equation $I_x = I_0 \cdot e^{-(k_1 + k_2 + k_3) \cdot x}$ where: —

I_x = Intensity at a depth of x metres,
I_0 = Intensity at a depth of 0 metres,
e = The base of natural logarithms,
k_1 = Coefficient of absorption (integrated from blue to red) of pure water = 0·035,
k_2 = Coefficient of absorption of the plankton algae,
k_3 = Coefficient of the residue (dissolved matter, particles, air bubbles, and other organisms).

In the basin of the pilot plant k_2 is the only absorption coefficient of importance. The bottom of the basin corresponds to the compensation point, since nearly all light is absorbed by the algae. It is assumed that 0·66 % of the blue + green + red light is found at the bottom. The depth in the oceans at which 0·66 % of the blue + green + red light at the surface is found corresponds to the depth where 1 % of the blue + green light is found — i. e., the compensation point according to Steemann Nielsen (1952). The absorption of the red light in the uppermost levels in the oceans is of no great importance as far as oceanic productivity is concerned. In the basin of the pilot plant the red light, however, is as important as the blue and green.

For the basin of the pilot plant we have $\frac{I_{c'}}{I_0} = e^{-k_2' \cdot c'} = 0{\cdot}66 \cdot 10^{-2}$, c' being the depth of the compensation point in metres. For an ocean (with a photosynthetic layer 120 m. deep) we have:—

$$\frac{I_{120}}{I_0} = e^{-(k_1'' + k_2'' + k_3'') \cdot 120} = 0.66 \cdot 10^{-2}, \text{ or } (k_1'' + k_2'' + k_3'') = 0.042.$$

$$k_2' \cdot c' = (k_1'' + k_2'' + k_3'') \cdot 120, \; k_2' = \frac{0.042 \cdot 120}{c'}$$

The values obtained in a laboratory for the coefficient of absorption in pure water (double distilled) cannot be used directly for an ocean of such water: the effect of scattering is not the same. If, however, all available information is employed (see Jerlov, 1952) it would be safe to estimate the coefficient of absorption k_1'' in an ocean of pure water at 0·035 (average value for a layer of 120 m.) integrated for the photosynthetically active part of the spectrum.

Putting first $k_3'' = 0$, we find $k_2'' = 0{\cdot}007$. As the coefficients, k_2, are proportional to the concentrations, a, of the algae, $\frac{k_2'}{k_2''} = \frac{a'}{a''}$ $\frac{0.042 \cdot 120}{0.007 \cdot c'}, \frac{120 \cdot a''}{c' \cdot a'} = \frac{0.007}{0.042} = \frac{1}{6}$, where $c' \cdot a'$ is the amount of algae per unit area in the basin of the pilot plant and $a'' \cdot 120$ is the amount per unit area in the photosynthetic layer of the ocean. The amount of algae in the ocean (0—120 m.) is thus one-sixth of the amount in the basin of the pilot plant.

In the example above, k_3'' was assumed to be 0, but the pure water and the plankton algae do not account for all the absorption and scattering of light in the oceans. Additional factors that may be mentioned are:— other organisms that are not autotrophic — principally bacteria and animals; suspended material of inorganic or organic origin; dissolved organic substances — principally "Gelbstoff"; and bubbles of air. We are no doubt safe in presuming that in clear oceanic water only about 50 % of the absorption not due to the water itself is due to the living plankton algae, or in other words, $k_2'' = k_3''$. As $k_2'' + k_3'' = 0{\cdot}007$, $k_2'' = 0{\cdot}0035$, which means that the amount of algae in the ocean considered is only about one-twelfth of the amount in the pilot plant.

With the same light falling on the surface, the light intensities in the basin of the pilot plant and in the ocean are identical at depths representing the same fraction of the respective photosynthetic layers. Let us compare two very thin layers of water in the basin of the pilot plant and in the ocean respectively. These layers are situated at depths of equal light intensity — i. e., at depths that are the same fractions of the photosynthetic layer. The thickness of the layers is proportional to the thickness of the respective photosynthetic layers. The rates of photosynthesis in the two layers are thus proportional to their content of algae. The rate in the whole photosynthetic layer is the sum of the rates in all layers present and is consequently proportional to the amount of algae present per unit area.

According to this reckoning, the rate of photosynthesis in an ocean (with a photosynthetic layer 120 m. deep) is about one-twelfth of the rate found in the pilot plant.

This value is, however, still too high. The plankton algae in ocean regions with very transparent water grow under conditions far below the optimum occurring in the pilot plants. In the first place, the concentrations of nutrient salts are not optimal. If growth conditions were better, the increasing population of plankton algae would soon render the water less transparent, thus diminishing the depth of the photosynthetic layer.

It is not astonishing to find therefore that the maximum rate of gross production found in the oceans with a photosynthetic layer more than 100 m. thick is only 5 % of the rate possible in the pilot plant (see Table 1) and that the average rate is only about 2 % of this rate. The waters of the Sargasso Sea are transparent because of the insignificant rate of organic production that occurs there as a result of the poor supply of nutrient salts.

8. Organic Productivity at Different Depths in the Oceans Measured per Unit Volume.

In the foregoing sections, the rate of production has been stated per square metre of the surface, since only in that way can the different regions of the sea be compared *inter se*. The rate of organic production

Table 2. Selected "Galathea" stations.

St. No.	Date	Position	Depth of the sample in m.	Temperature °C.	S ‰	Phosphate µg.-atoms P per litre.	Depth of photosynthetic layer in m.	Organic gross production in mg. C per m.³ per hour at 18,000 Lux (correct temperature).	Organic gross production at the surface (natural light conditions) in mg. C per m.³ pr. day.	Organic gross production below one m.² in g. C per day.
690	16/3 1952	11°0′S.	0	29·58	34·99	0·2		0·19		
		171°07′W.	60	29·48	35·01	0·2	120	0·21	1·6	0·15
			120	26·59	35·97	0·4		0·39		
691	17/3 1952	6°30′S.	0	29·45	35·19	0·2		0·19		
		169°42′W.	60	29·22	35·35	0·2	113	0·27	1·6	0·14
			105	27·59	35·97	0·5		0·17		
765	9/6 1952	35°16′N.	0	21·13	36·24	0·1		0·15		
		33°50′W.	40	18·34	36·20	0·1	76	0·70	1·3	0·16
			80	16·34	36·17	0·2		0·17		
696	24/3 1952	19°57′N.	0	24·02	34·83	0·1		0·20		
		158°10′W.	52	23·95	34·82	0·1	101	0·18	1·7	0·10
			92	23·57	35·01	0·1		0·17		
764	7/6 1952	31°35′N.	0	22·71	36·94	0·1		0·057		
		43°31′W.	60	21·46	36·96	0·1	121	0·069	0·48	0·048
			120	19·82	36·74	0·1		0·11		
693	20/3 1952	4°23′N.	0	28·02	35·08	0·3		0·61		
		164°44′W.	40	27·80	35·08	0·3	81	0·63	5·2	0·26
			80	27·63	35·10	0·3		0·52		
132	22/12 1950	17°13′S.	0	16·77	35·52	1·3		18·0		
		11°27′E.	15	16·72	35·52	1·3	19	15·4	152	1·9
			30	16·70	35·55	1·5		17·7		
138	24/12 1950	22°45′S.	0	15·73	35·05	1·3		7·5		
		14°15′E.	15	12·48	35·10	1·8	39	0·92	63	0·85
			30	12·20	35·08	1·8		0·16		
139	24/12 1950	Anchorage Walvis Bay	0	19·80	35·26	>1·6	0·8	780	6600	3·8

as measured by volume is, however, also of considerable interest. It is undoubtedly of importance to the grazing of animals whether the plankton algae are concentrated in a shallow layer or dispersed through a deep layer. Moreover, although the plankton algae are for the most part fairly evenly distributed throughout the photosynthetic layer, this is by no means always so.

Table 2 gives the values of the rate of organic production per cubic metre at different depths for characteristic stations. Other data are given in addition, e. g., temperature, salinity, concentration of inorganic phosphate, and depth of the photosynthetic layer.

St. 690 and St. 691 from the section across the Pacific Ocean are typical of tropical and subtropical parts of the oceans. No upwelling of deep water occurs, but some nutrient salts are constantly brought into the photosynthetic zone through mixing with the water masses

rich in nutrients just beneath it. As the water masses are stratified to a slight extent only — cf. Table 2 — the benefit of the mixing is felt most in the lower levels of the photosynthetic zone. The rate of organic production at the surface is only about half the rate found in the layer with the highest rate at the same light intensity.

If the water masses of the photosynthetic zone are almost without stratification, the rates of production at the same light intensity are nearly the same at all depths inside the zone. To exemplify this, the results from St. 696, from the Pacific, are given in Table 2.

If, on the other hand, the stratification is very pronounced, a wider range occurs in the rates of production at the various depths at the same light intensity. The rate at a depth of 40 m. at St. 765 from the North Atlantic Current was thus nearly 5 times the rate at the surface.

At St. 764 in the Sargasso Sea typical "old" surface water was found. Although the water masses just below the photosynthetic zone are rather poor in nutrient salts — see p. 315 — the rate of production at a given light intensity is definitely higher in the lower part of the photosynthetic zone than near the surface. The supply of nutrient salts to the plankton algae is relatively more abundant near the lower boundary. A contributory cause may be an increase in the rate of regeneration of the nutrient salts with depth, due to the sinking of organic material.

St. 693 from the Pacific provides an example from an area near — but not within — a divergence. The fairly high and even rate of organic production at all depths is due to the favourable nutrient conditions and to the lack of stability in the water column throughout the whole photosynthetic zone.

St. 132 and St. 138 are situated in the Benguela Current, where upwelling occurs. The rate of organic production is high at St. 132. The water masses rich in phosphate are evenly mixed down to at least 30 m. The rate of production, at the same light intensity, is nearly the same from the surface down to at least 30 m., although the lower limit of the photosynthetic zone is only 19 m.

At St. 138 the phosphate concentration at all depths is also high. However, the rate of organic production at 18,000 lux is high only at the surface. Although the depth of the photosynthetic layer is 39 m., the rate is low at depths of 15 and 30 m. The low temperature at these depths indicates very recent upwelling of water masses from medium depths. The surface temperature of 16°C., on the other hand, is an indication that some heating has occurred, and some time must have elapsed since the water just at the surface rose. Water masses in the photosynthetic zone can be too "new"; it takes some time before a considerable population of plankton algae develops in the water masses brought up to the euphotic zone from the aphotic zone below (cf. Sverdrup and Allen, 1939).

Calculated per unit volume, the most productive station on the "Galathea" Expedition — St. 139, Walvis Bay — yielded a rate of production at the surface 14,000 times the rate at the surface at St. 764 in the Sargasso Sea. Calculated per unit area, the rate at the Walvis Bay

station is, however, only 80 times higher. The differences in the depths of the photosynthetic zones — 0·8 and 121 m. respectively — account for the differences in the rates.

9. Conclusions.

The "Galathea" investigations described in this article enable it to be stated that the laws governing organic productivity in the tropical and subtropical parts of the oceans are not very complex. This does not, of course, mean that there is no reason to make further investigations in this field. Quite the opposite; it is an argument for intensifying such studies. It is important to possess detailed knowledge of the organic productivity in the sea in all parts of the earth, in order to understand better the conditions affecting the production of fish and other marine animals.

Regions of primary interest to fisheries are mostly fairly near the coasts. The organic production in coastal areas is often of a somewhat more complicated nature than that occurring in the tropical and subtropical parts of the open oceans.

APPENDIX.

Riley's Estimates of Organic Productivity in the Sargasso Sea.

When describing the Carbon-14 method for measuring productivity in the sea, I questioned the value given for oceanic productivity in nearly all modern textbooks of plant physiology. This value, which is of the order of 10 times the probable value obtained from the measurements made by the "Galathea" Expedition, originates from the excellent compilatory work on photosynthesis by Rabinowitch, 1945.

Rabinowitch used values obtained from experiments made by Riley. These experiments — determinations of oxygen changes in clear and dark bottles containing natural sea water — were therefore subjected to detailed examination.

In order to clarify matters as much as possible, special attention was paid to Riley's investigations in the oligotrophic Sargasso Sea (Riley, 1939). In these experiments, which lasted 3 days, oxygen was found to have been consumed in both the dark and the clear bottles — in the latter, however, to a much lesser degree. Past experience would attribute the high oxygen consumption in the dark bottles to the respiration of bacteria developing on the inner surfaces of the bottles. The reason for the low oxygen consumption in the clear bottles was, in Riley's view, the result of the photosynthetic activity of the phytoplankton. Since, however, this implied a gross organic production of up to about 4·5 g. C per $m.^2$ per day (St. 3513) — a productivity higher even than in Walvis Bay, the most productive area

Table 3.

Surface water collected 3. June 1953 in the Sargasso Sea, filtered through filter paper.

A. Experiments (R i l e y' s method) 3/6—6/6

	Initial values		Clear bottles		Dark bottles	
a	6·58	6·59 mg. O_2/l	6·63	6·61 mg. O_2/l	6·39	6·37 mg. O_2/l
b	6·57				6·37	
c	6·61		6·59		6·36	

O_2-consumption per litre in 3 days 0·22 mg.

"O_2-production" per litre in 3 days 0·24 mg.
$= 3 \times 10^{-2}$ mg. C per litre per day.

B. Experiment (C-14 method)

Assimilation per day (12 hours at 18,000 lux) $1{\cdot}7 \times 10^{-4}$ mg. C per litre.

investigated by the "Galathea" Expedition — R i l e y' s explanation of his experiments was considered unacceptable. Instead, it was suggested that by subtracting the oxygen content in the dark bottles from that in the clear bottles, it was simply the bactericidal effect of sunlight that was demonstrated. R i l e y (1953) describes this "... attack on the oxygen method ..." as "... empty as it is violent ...", but admits "that the C^{14} technique ... is superior in sensitivity and accuracy".

In the early spring of 1952, when the article describing the Carbon-14 method was written, the "Galathea" had not visited the Sargasso Sea. However, early in June 1952 the "Galathea" crossed this region on the way back from Panama to Europe. Since R i l e y' s experiments were made in 1939, at about the same time of the year — only about a week earlier — the opportunity was taken to compare R i l e y' s technique with the Carbon-14 method. Table 3 gives the results of these experiments. In order to reduce the rate of photosynthesis, the water was filtered through filter paper. The rate of photosynthesis was thereby reduced to about one-quarter, measured according to the tracer technique. Both the dark and the clear bottles (R i l e y' s technique) were placed in running water in a tub on deck for three days. The measurement by the tracer technique was made in artificial light (18,000 lux) for 5 hours. The oxygen experiments yielded statistically significant values. The oxygen consumption in 3 days was 0·22 mg. per litre. The "oxygen production" — values from the clear bottles minus the values from the dark bottles — was 0·24 mg. per litre in 3 days. The mean values of R i l e y' s experiments in May 1939 were nearly the same.

An "O_2-production" of 0·24 mg. per litre in 3 days implies a carbon uptake of 3×10^{-2} mg. per litre per day. According to the tracer experiment, photosynthesis per day is only $^1/_{200}$ of this, i. e., $1{\cdot}7 \times 10^{-4}$ mg. C per litre. R i l e y' s technique, in this case, gives values 200 times as great as does the tracer technique. It would appear therefore that the "O_2-production" obtained by the oxygen technique cannot be due to photosynthesis.

However, it does not follow, of course, that the "O_2-production" is due to the bactericidal effect of sunlight. In my 1952 article I suggested this idea as a possibility. Another, possibly more plausible hypothesis is that the effect of sunlight may be indirect. It is known that plankton algae (*Chlorella*) produce antibiotics (P r a t t et al., 1944). As this production increases in light — dependent on photosynthesis — light might reduce the bacterial activity in the clear bottles.

Since the results of the experiments given in Figure 3 clearly show that the difference in the oxygen content of the clear and the dark bottles after 3 days does not represent photosynthesis when oligotrophic oceanic water is used for the experiments, the arguments advanced by R i l e y (1953), in support of his Sargasso Sea production values, would not appear to be tenable. In Section 7 it was shown that a high rate of production is theoretically precluded by the depth of the photosynthetic layer in the Sargasso Sea. A marked negative correlation exists between the depth of the photosynthetic layer and the rate of production. Ri l e y (1953) estimates the average photosynthetic production of carbon in the Sargasso Sea as at least 400 mg. per day. This figure, which would appear to be nearly 10 times too high, is derived from estimates of zooplankton food requirements, but details of the computation are, however, not given.

Summary.

1) In the present paper some of the main results of measurements of organic production made on the Danish "Galathea" Expedition are described. A special method using radio-active carbon (^{14}C) was employed. The values obtained on the passages across the Pacific and Atlantic Oceans are given, as are also those for the most productive area investigated, the southern part of the Benguela Current.

2) The amount of organic production in tropical and subtropical parts of the oceans is strictly dependent on hydrographic conditions. The supply of nutrients from below — manifested through the "age" of the surface water — is by far the most important factor governing the production of phytoplankton. Outside areas with a pronounced upwelling of water, light intensity seems to be of little importance as a limiting factor in the tropics and subtropics. The rate of photosynthesis below a unit surface is only slightly reduced by weather conditions. The rate is reduced by about 75 % on extremely dark days only.

3) It is shown that a marked negative correlation exists between the depth of the photosynthetic layer and the rate of production, and, further, that a high rate of production is theoretically impossible with a depth of photosynthetic layer such as occurs in the clearest ocean waters.

4) Four different oceanic regions classified by the amount of organic production are described. In the most productive regions (those of upwelling water), organic production is from 0·5 to about 3 g. C per square metre per day. In the least productive areas (with typically "old" surface water) the rate is about 0·05 g./m.^{2}/day.

5) Calculated per unit volume, the surface rate at the most productive station (Walvis Bay) was 14,000 times the rate at the surface of the Sargasso Sea, one of the least productive areas investigated by the "Galathea". Calculated per unit surface, the rate at the Walvis Bay station is only 80 times higher. The difference between the depths of the two photosynthetic zones — 0·8 and 120 m. respectively — accounts for the difference in the rates.
6) The average gross production over all oceans is estimated to be about 0·15 g. C/m.^{2}/day. The net production for the whole hydrosphere is thus about $1{\cdot}5 \times 10^{10}$ tons of carbon per year.

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Observations on Coccoliths of *Syracosphaera mediterranea* Lohm., *S. pulchra* Lohm., and *S. molischi* Schill. in the Electron Microscope.

By

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AN important part of the phytoplankton population in the warmer open ocean consists of coccolithophorids. Some of them, for instance *Coccolithus huxleyi* (Lohm.) Kampt., may also occur in vast numbers in the coastal waters of higher latitudes and cause discoloration of the sea. The coccolithophorids are minute flagellates (mostly 4—20 μ) and are not usually caught by plankton nets. Their cells are covered by calcified elements (coccoliths) of varied shape and structure.

The taxonomy of the group is to a great extent based upon the morphology of the coccoliths. Recently the electron microscope has been used for obtaining further information on their structure (Braarud and Nordli 1952, Braarud *et al.* 1952, Deflandre and Fert 1952 and 1953, Kamptner 1952, Halldal and Markali 1953).

The method now used for preparing specimens of coccoliths for electron microscope studies is by drying on the electron microscope grid.

As the coccoliths are more or less flat in shape, they are mostly observed normal to the base. When a part of the collodion or formvar films is exposed to violent electron radiation, the film often cracks and the coccoliths may then be studied at different angles.

By examining a great many samples in the electron microscope and combining these observations with those in light microscopes, Braarud *et al.* (l. c.) and Halldal and Markali (l. c.) succeeded in obtaining detailed information on the morphology of the coccoliths from four different genera: *Coccolithus*, *Syracosphaera*, *Anthosphaera*, and

Calyptrosphaera. The present paper deals mainly with the structure of coccoliths belonging to the commonest type, the discolith, described on the basis of light microscope observations. Discoliths are cup- and saucer-shaped coccoliths with their concave side facing outwards (Figure 1). The outline is slightly elliptical or almost circular. A hump, a spine, or a rod usually protrudes from the base.

Figure 1. Cross-section of a discolith (a) and a placolith (b) as seen in a light microscope.

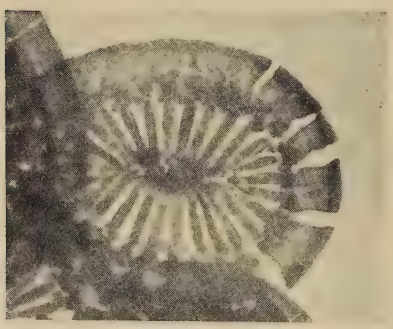
The coccolithophorids analysed in this paper (*Syracosphaera mediterranea, S. pulchra,* and *S. molischi*) have been isolated from preserved sea water samples collected at Weather Ship Station M (66°N., 2°E.) in the Norwegian Sea.

***Syracosphaera mediterranea* Lohm.**

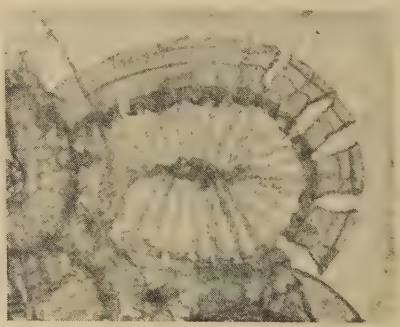
In Figure 2a a discolith from *Syracosphaera mediterranea* is seen in half side view. The coccolith is more or less covered by the cracked formvar film, but the outline of the film can be clearly distinguished from that of the coccolith. Schematically this coccolith may be divided

a) electron micrograph in half side view.

b) model in about the same angle of view.



c) seen from above.



d) the latter after treatment with hydrochloric acid.

Figure 2. Coccoliths of *Syracosphaera mediterranea* Lohm.

into four parts (see Figure 3):— (1) The bottom consists of 28 flat ribs (the numbers mentioned in this description may vary from one coccolith to the other), arranged at right angles to the elliptical outline. The bottom is concave, so it presumably fits the form of the cell. (2) The cylindrical wall is split up into alternately broad and narrow elements, 56 in all. The narrow elements end in an arch ca. 0·1 μ from the edge

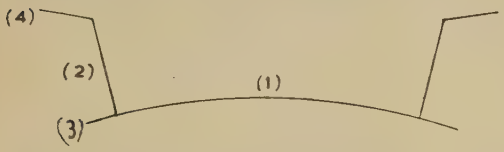
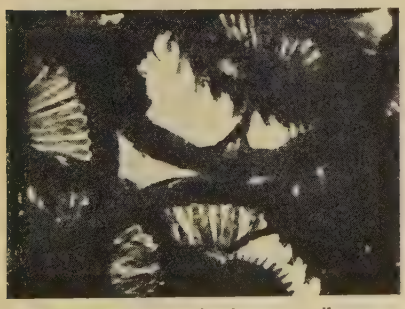


Figure 3. Cross-section of a *Syracosphaera mediterranea* discolith. 1) bottom, 2) wall, 3) lower rim, 4) upper rim.

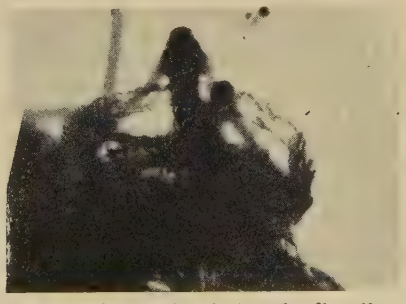
of the wall. (3) The structure of the lower rim is closely connected with that of the wall, the narrow elements in the wall continuing as spade-shaped elements of the lower rim, the broad ones as tapering elements. (4) The upper rim is split up into 28 elements which are evenly corrugated.

a) surrounding a disintegrated cell.

b) seen slightly from the side.



c) details of the bottom ribs.



d) one of those bordering the flagellar field.

Figure 4. Coccoliths of *Syracosphaera pulchra* Lohm.

The regularity of this structure is accentuated by the reciprocal arrangement of the elements of the various parts. Each rib in the bottom corresponds to a broad element in the wall, which again corresponds to the centre of an element in the upper rim.

***Syracosphaera pulchra* Lohm.**

Following the division used in the description of *Syracosphaera mediterranea* (see above), we notice:— (1) The bottom of the ordinary coccoliths has a central solid part bearing a hump in the middle (Figure 4b). The number of ribs going from the central area to the lowest part of the wall varies between 40 and 50. Half way between the central part and the wall each rib is split obliquely (Figure 4c). This may be caused by mechanical stress during drying, but its frequent occurrence indicates that the split represents a true detail in the morphology. Such splits have been observed occasionally in other species which have flat ribs. (2) We have been unable to study the structure of the wall as closely as in *S. mediterranea,* but some electron micrographs indicate a great degree of conformity in the wall structure of these two types (Figure 4b). In *S. pulchra* we find 30—40 pairs of alternately broad and narrow elements, their numbers being somewhat less than that of the ribs. (3) The lower rim consists of alternately spade-shaped and tapering elements connected with those in the wall, as in *S. mediterranea* (see Figure 4c). (4) Each separate element of the upper rim in *S. pulchra* is arranged in a similar way to that in the upper rim of *S. mediterranea,* but with one exception; this rim is curled instead of corrugated.

The general arrangement in the structure of *S. pulchra* does not show the same degree of regularity as in *S. mediterranea.* In *S. pulchra* the number of ribs in the bottom is somewhat higher than the number of elements in the upper rim, and the regular correspondence between elements in the bottom and upper rims does not seem to exist.

The coccoliths bordering the flagellar field bear a spine or rod in the middle of their base. These coccoliths are smaller in size and the outline, as seen from above, is more circular (Figure 4d) than the others.

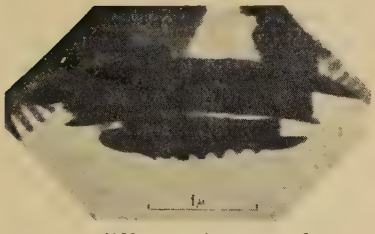
The coccolith size within this species seems to vary from one area to the other. The size of the coccoliths of *Syracosphaera pulchra* observed in our material is somewhat less than mentioned by K a m p t n e r (1941), but agrees with those shown in S c h i l l e r' s (1930) figures.

***Syracosphaera molischi* Schill.**

(1) The bottom consists of 30—35 flat ribs. The central part is developed in different ways; as a solid central area (some coccoliths in Figure 5b), as a solid central area surrounded by a ring, or as two separate rings, or with transitions between these designs (Figure 5a). Each rib exists as a unit through the central pattern and ends in a flat taper which is wedged between the ribs coming from the opposite side (Figure 5f). The ribs are, however, closely connected with the central structure, as may be particularly well seen in the coccoliths shown in Figure 5a, and in those treated with hydrochloric acid. (2) The wall is

a) showing the different developments in the central part.

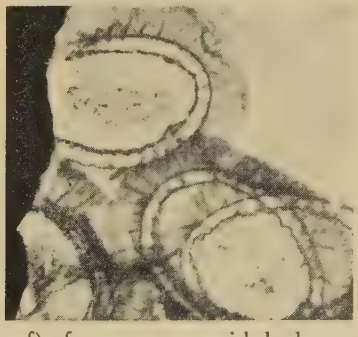
b) surrounding a disintegrated cell.



c) two different sizes seen from the side.

d) some of the coccoliths bordering the flagellar field.

e) a coccolith with its bottom torn away from the rest of it.



f) after treatment with hydrochloric acid.

Figure 5. Coccoliths of *Syracosphaera molischi* Schill.

0·2—0·3 μ high (Figure 5c). Its microstructure is best studied in the coccoliths treated with hydrochloric acid (Figure 5f). When seen from above, the wall appears as an area between the bottom and the broad upper rim. The lightest parts in these hydrochloric acid-treated coccoliths are those containing the greatest amount of $CaCO_3$. A secondary system of $CaCO_3$-rich elements may be developed and extend as spines from the wall towards the centre (Figures 5a and 5e). Each rib in the bottom corresponds to one of these elements. In the interval between the $CaCO_3$-rich elements in the wall the organic matter is more abundantly present. (3) The lower rim is definitely narrower than the upper one (Figure 5c). The number of elements is the same as the number of ribs in the bottom and the number of elements in the upper rim. (4) The $CaCO_3$-rich "shovels" appear to fortify a part of the elements in the upper rim. The rest of the upper rim is poorer in $CaCO_3$.

The coccoliths bordering the flagellar field are smaller than the ordinary ones, and when seen from above, they are more circular in outline and the breadths of the upper and lower rims are about the same. The central part is shaped like a spine or rod, which is split along its long axis into two or three closely connected elements (Figure 5d).

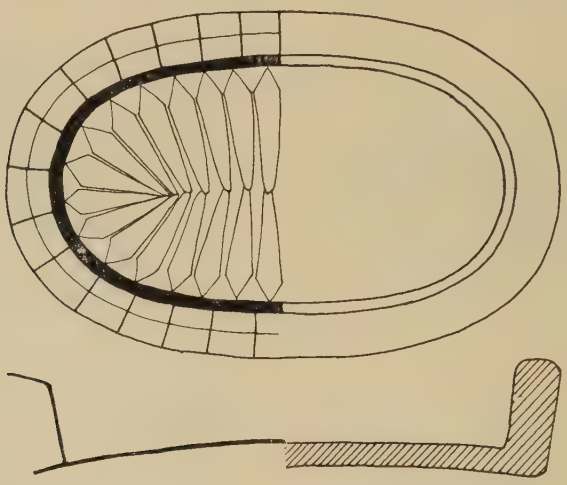


Figure 6. The discolith-type dealt with in this paper (simplified) as seen in former light microscope observations (right) and in the electron microscope (left).

Comparison of electron microscopy with light microscopy.

It is of particular interest to compare the electron micrographs in this paper with the pictures obtained in a light microscope. The resolving power of a light microscope is limited to about 0·2 μ. This means that neither the upper nor the lower rim, when seen directly from the side, can be resolved in a light microscope, as the thickness scarcely exceeds 0·1 μ. On the other hand, the upper rim, being about 0·4 μ

broad, can easily be resolved when seen from above. Consequently we are of the opinion that the breadth of the rim when seen from above in a light microscope has been interpreted as the thickness of the discolith wall (see Figure 6).

The coccoliths which have hitherto been studied in electron microscopes have displayed a great variety of designs. Those described above seem to have many similarities with unidentified coccoliths depicted by Deflandre and Fert (l. c.) and with some which we have observed in water samples from the Norwegian Sea and the Faroe—Shetland Channel (unpublished).

On the other hand, they differ completely from the coccoliths in *Syracosphaera carterae* (Braarud et al. 1952), which, when examined in a light microscope were recorded as discoliths (Braarud and Fagerland 1946). Finally we may mention the many features common to the coccoliths of both *Syracosphaera mediterranea* and *Coccolithus huxleyi*, as the latter also has a bottom, a wall, and lower and upper rims (Braarud et al. 1953). This last comparison is of special interest, since *Coccolithus huxleyi*, on the evidence from light microscope observations, by Kamptner (1943), was transferred some years ago from the genus *Pontosphaera* (a genus with discoliths; see Figure 1a) to its present place (a genus with placoliths; see Figure 1b).

During the short time electron microscopy has been used in the investigation of coccolithophorids, it has become apparent that the taxonomy of this group needs to be reviewed on several points. However, far more observations are needed to obtain a satisfactory rearrangement of the species.

Summary.

(1) Coccoliths of the discolith type were studied in the electron microscope, single cells of *Syracosphaera mediterranea* Lohm., *S. pulchra* Lohm., and *S. molischi* Schill. being isolated from preserved sea water samples. (2) According to the electron micrographs these coccoliths consist of four parts, viz., bottom, wall, lower and upper rim. (3) The reciprocal arrangement of the elements in these different parts showed a high degree of regularity. (4) The electron micrographs were compared with the picture in an ordinary light microscope. (5) These species of the genus *Syracosphaera* show a coccolith morphology which is different in principle from that of *S. carterae* Braarud and Fagerland.

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Use of Otoliths for Determining the Age of Several Fishes from the Bering Sea.

By

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SINCE there are few areas in the world today where the fishery stocks are not being exploited to some extent, the opportunity to study virgin populations is rare. Such an opportunity arose in June and July 1949 when the vessel "Deep Sea" was chartered by the U. S. Fish and Wildlife Service to investigate the fishery potentialities of the Bering Sea where previously there had been no regular trawl fishery[1]). Since information on the age-groups present in these virgin populations was of primary importance, it was first necessary to develop methods of determining the ages of the several species of bottom fish. The procedures described herein may be applicable in studies elsewhere of similar species.

The catch was predominantly of six species:—

Pacific cod (*Gadus macrocephalus* Tilesius)
Alaska pollack (*Theragra chalcogramma* Pallas)
or whiting
Pacific halibut (*Hippoglossus stenolepis* Schmidt)
Lemon sole (*Pleuronectes quadrituberculatus* Pallas)
Rock sole (*Lepidopsetta bilineata* Ayres)
Starry flounder (*Platichthys stellatus* Pallas)

Otoliths were collected from all of these species as well as from a single specimen of yellowfin sole (*Limanda aspera* Pallas). For comparison a few scale samples were taken from the cod.

Techniques of Preparing the Otoliths for Age Study.

Otoliths taken in the field from fresh fish, or in the case of the lemon sole, from fish frozen aboard, were preserved dry in coin envelopes bearing identifying numbers. Upon gross examination in the laboratory

[1]) For details of this exploratory cruise, see Ellson, Powell, and Hildebrand, 1950.

the otoliths could be divided into two groups according to size and shape. Those of the Pacific cod and Alaska pollack were longer than wide, somewhat pointed at the ends, serrated along each edge, and crescent-shaped. The largest otoliths from this group measured 25 mm. by 11 mm. by 4 mm. and were taken from a cod 83 cm. in length. The other group consisted of flatfishes whose otoliths were somewhat disk-shaped with various irregularities. The largest earstones, 16 mm. by 2 mm. in size, were found in a halibut 124 cm. in length (se Figure 1).

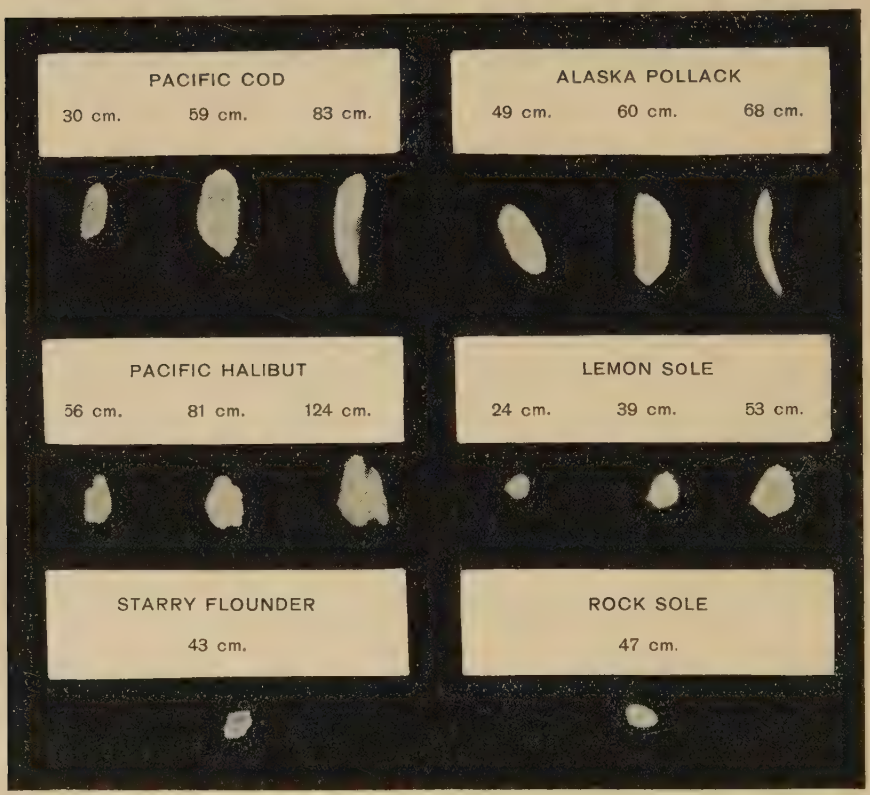

Figure 1. Showing relative size and shape of otoliths from species collected. Largest cod and pollack otolith shown in side view.

Previous workers have obtained variable results in the use of otoliths for age determination in the bottom fishes. Numerous references found in the literature indicate the value of otoliths in the study of the Norwegian cod. Thompson (1914) determined the age of Pacific halibut from otoliths, and workers of the International Fisheries Commission have used otoliths in their halibut studies for many years. On the other hand, Harold G. Orcutt (1950) chose scales instead of otoliths in his research on the starry flounder in California waters and

F. C. Cleaver (1949) working with the starry flounder in Washington waters found the otoliths unsatisfactory for age determinations.

In the study of the Bering Sea collection a number of methods were tried in order to find the one which brought out most clearly the annular marks in each type of otolith. In every case interpretation of the otoliths was improved considerably by grinding the stones on a lapidary wheel using No. 600 abrasive. Because of the variation between species, the most successful procedures are considered separately.

Cod (*Gadus macrocephalus*) and pollack (*Theragra chalcogramma*). These otoliths remained opaque after soaking for weeks in Canada Balsam or glycerine, or even after boiling in these media. No mounting procedure, surface grinding or polishing gave any indication of internal markings whatever. A method in use by the Norwegian investigators in the study of their cod fishery and described orally by Mr. G. Rollefsen proved satisfactory with slight modification.

In this procedure the otolith was broken with the fingers transversely near the middle. To obtain the best definition of the marking, the broken surface was ground, washed, and dipped in glycerine. The piece of earstone was held upright on a microscope slide with wax or modelling clay, and the ground surface examined with a binocular microscope of suitable power. A beam of light from a microscope lamp was directed at right angles to the body of the otolith and when a finger or other object was held in exactly the right position to shade the ground face, the light travelled up through the internal layers to appear on the surface as a series of light and dark bands.

Lemon sole (*Pleuronectes quadrituberculatus*). Even after treatment in various media, no external evidence of annuli could be found on otoliths of this species except in the smallest specimens. However, after they had been ground nearly to the middle from opposite sides leaving a thin section of the earstone for study, the markings became evident. When the otoliths were examined over a black mat in reflected light, the annuli could be seen clearly.

Halibut (*Hippoglossus stenolepis*) and rock sole (*Lepidopsetta bilineata*). Although in some cases these earstones could be read if immersed in glycerine, the markings became much clearer when the concave surface was lightly ground.

Starry flounder (*Platichthys stellatus*) and yellowfin sole (*Limanda aspera*). The earstones of these species show only faint markings when dry or in glycerine, but by removing the opaque surface layer the annuli could be read without difficulty.

Age Determination Procedures.

Two readings of each pair of otoliths were made a day or more apart without reference to the fish length or the previous reading. If the two readings were not the same, a third reading was made at least a day later, and a decision reached as to the most probable age of the fish from which the earstones came. Excepting 33 of the cod specimens which

were selected to represent the smaller sizes, all the fish in the collections were 5 years old or older. Since a reader has less chance of obtaining the same count twice in succession from older fish, the age compositions of virgin stocks containing older fish should give a lower percentage of agreement than those stocks which are regularly fished.

Although the percentage agreement of the first two readings bears some relation to the accuracy of the age determinations, and indicates the clarity of the markings, it is not possible to estimate the degree of accuracy from the limited collections available. Comparisons of ages for such species as are available indicate that the fish from the Bering Sea are slower growing and attain a greater age than similar fish from localities farther south. This is as expected.

Consistency of Results.

For the cod the first two readings were the same in 64·2 per cent. of the cases. All but seven of the age counts differed by only one year.

For the pollack the two readings agreed in 26 per cent. of the cases. The greater difficulty in interpreting these otoliths was attributed to (1) the slower growth-rate of these fish producing annuli closely crowded near the margin of the otolith, and (2) the greater confusion between true and false annuli found in this species. More collections from the Bering Sea with greater numbers of smaller fish are needed to substantiate the usefulness of these techniques in the age determination of the pollack.

For the lemon sole, 64·2 per cent. of the two readings were the same, indicating a fair degree of consistency in interpretation of the earstones. An interesting feature of the otoliths of this species was the central zone, containing the first 3 to 7 annuli, and resembling the freshwater portion of a sockeye salmon otolith. Beyond this zone, the annuli are less distinct and much farther apart as in the ocean growth portion of the sockeye earstone.

This growth pattern suggests that the young of the lemon sole grow very slowly for a few years. Possibly the nursery grounds are in brackish or inside waters, or in localities where they are crowded by the same or other species. After a varying period of time, they grow more rapidly perhaps by migration to areas of more abundant food or better growth conditions, or by the onset or result of sexual development.

For the other species, too few specimens were available to provide accurate information on the percentage agreement between the first two readings, although they indicated that the markings can be read with substantial consistency.

Mortality and Growth-Rates.

Because of the small size of most of the samples, no attempt has been made to determine the natural mortality rates of the different stocks of

Table 1. Age and Size Analysis of Pacific Cod from Bering Sea.

Length (cm.)	Age in Years (Number of Rings) 1	2	3	4	5	6	7	8	9	10	11	12	Sample Total
14·1—16·0	1	—	—	—	—	—	—	—	—	—	—	—	1
16·1—18·0	2	—	—	—	—	—	—	—	—	—	—	—	2
18·1—20·0	4	—	—	—	—	—	—	—	—	—	—	—	4
20·1—22·0	—	1	—	—	—	—	—	—	—	—	—	—	1
22·1—24·0	—	—	—	—	—	—	—	—	—	—	—	—	—
24·1—26·0	—	—	—	—	—	—	—	—	—	—	—	—	—
26·1—28·0	—	3	—	1	—	—	—	—	—	—	—	—	4
28·1—30·0	—	—	2	—	—	—	—	—	—	—	—	—	2
30·1—32·0	—	1	3	—	—	—	—	—	—	—	—	—	4
32·1—34·0	—	—	1	—	—	—	—	—	—	—	—	—	1
34·1—36·0	—	—	—	—	—	—	—	—	—	—	—	—	—
36·1—38·0	—	—	2	3	—	—	—	—	—	—	—	—	5
38·1—40·0	—	—	1	1	—	—	—	—	—	—	—	—	2
40·1—42·0	—	—	—	1	—	—	—	—	—	—	—	—	1
42·1—44·0	—	—	—	—	1	—	—	—	—	—	—	—	1
44·1—46·0	—	—	—	4	—	—	—	—	—	—	—	—	4
46·1—48·0	—	—	—	1	—	—	—	—	—	—	—	—	1
48·1—50·0	—	—	—	—	—	—	—	—	—	—	—	—	—
50·1—52·0	—	—	—	—	1	—	—	—	—	—	—	—	1
52·1—54·0	—	—	—	—	2	—	—	—	—	—	—	—	2
54·1—56·0	—	—	—	—	6	1	—	—	—	—	—	—	7
56·1—58·0	—	—	—	1	1	1	—	—	—	—	—	—	3
58·1—60·0	—	—	—	—	2	—	1	—	—	—	—	—	3
60·1—62·0	—	—	—	—	1	1	3	—	—	—	—	—	5
62·1—64·0	—	—	—	—	—	3	—	—	—	—	—	—	3
64·1—66·0	—	—	—	—	1	2	3	2	—	—	—	—	8
66·1—68·0	—	—	—	—	—	3	—	—	—	—	—	—	3
68·1—70·0	—	—	—	—	2	5	3	1	—	—	—	—	11
70·1—72·0	—	—	—	—	—	3	2	—	1	—	—	—	6
72·1—74·0	—	—	—	—	1	1	3	3	2	1	—	—	11
74·1—76·0	—	—	—	—	—	2	3	3	—	—	1	—	9
76·1—78·0	—	—	—	—	—	1	—	3	—	2	—	—	6
78·1—80·0	—	—	—	—	—	—	2	1	—	—	—	—	3
80·1—82·0	—	—	—	—	—	—	—	—	3	—	—	—	3
82·1—84·0	—	—	—	—	—	—	—	—	—	—	—	1	1
84·1—86·0	—	—	—	—	—	—	—	—	—	—	1	—	1
86·1—88·0	—	—	—	—	—	—	—	—	—	2	—	—	2
88·1—90·0	—	—	—	—	—	—	—	—	—	1	—	—	1
90·1—92·0	—	—	—	—	—	—	—	—	—	1	—	—	1
Sample Total	7	5	9	12	18	23	20	13	6	7	2	1	123

fish. However, for future comparison, the main features of the results are summarized below:—

Species	Range of ages	Age of maximum numbers
Pacific cod	1—12*)	6
Alaska pollack	6—15	11
Pacific halibut	5—14	7
Starry flounder	5—13	—
Rock sole	9—15	11, 12

*) Samples selectively supplemented by fish under 5 years of age.

Table 2. Age and Size Analysis of Pollack from Bering Sea.

Length (cm.)	Age in Years (Number of Rings) 6	7	8	9	10	11	12	13	14	15	16	Sample Total
46·1—48·0	—	—	2	—	—	—	—	—	—	—	—	2
48·1—50·0	—	1	1	1	—	—	—	—	—	—	—	3
50·1—52·0	1	1	—	—	—	—	—	—	—	—	—	2
52·1—54·0	—	—	—	1	—	—	—	1	—	—	—	2
54·1—56·0	—	—	—	—	—	—	1	—	—	—	—	1
56·1—58·0	—	—	1	—	2	—	—	—	—	—	—	3
58·1—60·0	—	—	—	—	—	2	—	—	—	—	—	2
60·1—62·0	—	—	—	—	—	1	1	—	1	—	—	3
62·1—64·0	—	—	—	1	—	1	—	—	—	—	—	2
64·1—66·0	—	—	—	1	—	1	1	—	—	—	—	3
66·1—68·0	—	—	—	—	—	—	—	1	—	1	—	2
68·1—70·0	—	—	—	—	—	1	—	—	—	—	—	1
70·1—72·0	—	—	—	—	—	—	—	—	—	—	—	—
72·1—74·0	—	—	—	—	—	—	—	1	—	—	—	1
Sample Total	1	2	4	4	2	6	3	3	1	1	0	27

Similarly, there were too few fish present to establish valid growth-rates. For reference in future work the detailed results of the age determinations for these fish are given in Tables 1—6. In addition,

Table 3. Age and Size Analysis of Lemon Sole from Bering Sea.

Length (cm.)	Age in Years (Number of Rings) 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Sample Total
23·1—24·0	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
24·1—25·0	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	3
25·1—26·0	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
26·1—27·0	—	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	3
27·1—28·0	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	3
28·1—29·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
29·1—30·0	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
30·1—31·0	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	2
31·1—32·0	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
32·1—33·0	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	2
33·1—34·0	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	3
34·1—35·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35·1—36·0	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	2
36·1—37·0	—	—	—	—	—	3	—	—	—	1	—	—	—	—	—	—	4
37·1—38·0	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	3
38·1—39·0	—	—	—	—	2	—	2	2	—	—	—	—	—	—	—	—	6
39·1—40·0	—	—	—	—	1	—	—	1	2	1	—	—	—	—	—	—	5
40·1—41·0	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
41·1—42·0	—	—	1	—	—	—	1	—	—	1	—	—	—	—	—	—	3
42·1—43·0	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	2
43·1—44·0	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
44·1—45·0	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
45·1—46·0	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
46·1—50·0*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50·1—51·0	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	2
51·1—52·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
52·1—53·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
53·1—54·0	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	2
Sample Total	1	3	8	3	5	9	5	6	4	4	2	0	0	2	0	1	53

*) No records.

Table 4. Age and Size Analysis of Pacific Halibut from Bering Sea.

Length (cm.)	Age in Years (Number of Rings) 5	6	7	8	9	10	11	12	13	14	Sample Total
34·1— 36·0	1	—	—	—	—	—	—	—	—	—	1
36·1— 42·0*)	—	—	—	—	—	—	—	—	—	—	—
42·1— 44·0	1	2	—	—	—	—	—	—	—	—	3
44·1— 46·0	—	—	—	—	—	—	—	—	—	—	—
46·1— 48·0	1	—	—	—	—	—	—	—	—	—	1
48·1— 50·0	—	—	—	—	—	—	—	—	—	—	—
50·1— 52·0	—	—	1	—	—	—	—	—	—	—	1
52·1— 54·0	—	2	1	—	—	—	—	—	—	—	3
54·1— 56·0	—	—	1	—	—	—	—	—	—	—	1
56·1— 58·0	—	—	1	—	—	—	—	—	—	—	1
58·1— 60·0	—	—	—	2	—	1	—	—	—	—	3
60·1— 62·0	—	—	1	—	—	—	—	—	—	—	1
62·1— 64·0	—	—	—	—	—	—	—	—	—	—	—
64·1— 66·0	—	—	—	1	—	1	—	—	—	—	2
66·1— 74·0*)	—	—	—	—	—	—	—	—	—	—	—
74·1— 76·0	—	—	—	—	1	—	—	—	—	—	1
76·1— 78·0	—	—	—	—	—	—	1	1	—	—	2
78·1— 80·0	—	—	—	—	—	—	—	—	—	—	—
80·1— 82·0	—	—	—	—	1	1	1	—	—	—	3
82·1— 84·0	—	—	—	—	—	1	—	—	—	—	1
84·1— 86·0	—	—	—	—	—	—	1	—	—	—	1
86·1— 88·0	—	—	—	—	—	—	—	—	—	—	—
88·1— 90·0	—	—	—	—	—	—	—	1	—	—	1
90·1—124·0*)	—	—	—	—	—	—	—	—	—	—	—
124·1—126·0	—	—	—	—	—	—	—	—	—	1	1
Sample Total	3	4	5	3	2	4	3	2	0	1	27

*) No records.

Table 5. Age and Size Analysis of Starry Flounder from Bering Sea.

Length (cm.)	Age in Years (Number of Rings) 5	6	7	8	9	10	11	12	13	14	Sample Total
28·1—29·0	1	—	—	—	—	—	—	—	—	—	1
29·1—34·0*)	—	—	—	—	—	—	—	—	—	—	—
34·1—35·0	—	—	1	—	—	—	—	—	—	—	1
35·1—36·0	—	—	—	—	1	—	—	—	—	—	1
36·1—37·0	—	—	—	—	—	—	—	—	—	—	—
37·1—38·0	—	—	—	—	1	—	—	—	—	—	1
38·1—39·0	—	—	—	—	—	—	—	—	—	—	—
39·1—40·0	—	—	—	1	—	—	—	—	—	—	1
40·1—41·0	—	—	—	—	—	—	—	—	—	—	—
41·1—42·0	—	—	—	—	—	—	1	1	—	—	2
42·1—43·0	—	—	—	—	—	—	—	—	—	—	—
43·1—44·0	—	—	—	1	—	—	1	1	1	—	4
44·1—49·0*)	—	—	—	—	—	—	—	—	—	—	—
49·1—50·0	—	—	—	—	—	1	—	—	—	—	1
Sample Total	1	0	1	2	2	1	2	2	1	0	12

*) No records.

Table 6. Age and Size Analysis of Rock Sole from Bering Sea.

Length (cm.)	Age in Years (Number of Rings) 9	10	11	12	13	14	15	Sample Total
34·1—36·0	1	—	—	—	—	—	—	1
36·1—38·0	—	—	—	—	—	—	—	—
38·1—40·0	1	—	—	—	—	—	—	1
40·1—42·0	—	1	1	—	—	—	—	2
42·1—44·0	—	—	3	1	—	—	—	4
44·1—46·0	—	—	1	—	—	—	—	1
46·1—48·0	—	—	—	3	—	—	—	3
48·1—50·0	—	—	—	1	—	—	—	1
50·1—52·0	—	—	—	—	—	—	—	—
52·1—54·0	—	—	—	—	—	—	1	1
Sample Total	2	1	5	5	0	0	1	14

otoliths from one large specimen of yellowfin sole (*Limanda aspera*), a female 43·7 cm. in length, were examined; they indicated this fish to be 15 years old (in its 16th year).

Summary and Conclusions.

Age determinations from six species of fish collected in the Bering Sea in June and July 1949 were determined from the otoliths. The various procedures which were required to reveal the annuli for each species represented are described and the results presented in tabular form.

The results of this study indicate that all species examined can be aged satisfactorily if the otoliths are prepared properly. The limited collections made on this cruise point to the need for expanded study on all species to be found in this area.

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Etude Comparative du "Merlu Blanc" (*Merluccius merluccius* L.) et du "Merlu Noir" (*Merluccius senegalensis* Cadenat).

Par

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Institut des Pêches Maritimes du Maroc.

COMME nous l'avons déjà signalé (notes 1950—51 — *Journal du Conseil*, Vol. XVIII, No. 2), le "merlu blanc" (*Merluccius merluccius* L.) cohabite sur les côtes du Maroc, du Rio de Oro, et de Mauritanie, avec le "merlu noir" (*Merluccius senegalensis* Cadenat).

Nous donnons ici une étude comparative de ces deux espèces. Les exemplaires étudiés proviennent de Casablanca, d'Agadir, du Cap Juby, du Cap Draa, et de la côte de Mauritanie. Ils ont été pêchés durant les années 1950, 1951, et 1952.

I. Caractères métriques.

Ces caractères ont été étudiés chez 78 individus de même taille: 13 à 75 cm., de l'une et l'autre espèce.

A) Longueur relative de la tête.

Pour le "merlu noir" comme pour le "merlu blanc", les variations de l'indice $\frac{100\,T}{LT}$ indiquent assez nettement que la longueur relative de la tête décroit avec la taille, donc avec l'âge. La valeur minima de cet indice chez les jeunes est de 28·0 pour *M. merluccius* et de 27·7 pour *M. senegalensis*. Chez les grands merlus elle atteint 24·7 pour *M. merluccius* contre 23·1 pour *M. senegalensis*. La longueur relative de la tête paraît donc être légèrement plus petite pour cette dernière espèce que pour le *M. merluccius* L.

B) Distance prédorsale 1.

L'indice $\frac{100\,D}{LT}$ diminue également avec l'âge; chez le "merlu blanc" il varie de 29·1 à 25·4 et pour le "merlu noir" de 29·1 à 25·0. Il ne paraît pas y avoir de différence sensible, dans ce cas, entre les deux espèces.

C) Distance préanale.

L'indice $\frac{100\,A}{LT}$ contrairement aux deux précédents augmente légèrement avec la taille. Sa valeur chez le "merlu blanc" se situe entre 38·6 et 42·5 alors que pour le "merlu noir" elle est comprise entre 36·5 et 43·6. L'amplitude de variation est plus forte chez ce dernier. On ne peut cependant en déduire de différence précise.

D) Longueur de l'oeil par rapport à la longueur de la tête.

L'indice $\frac{100-Œ}{LT}$ a été calculé pour 20 merlus noirs et 23 merlus blancs; chez l'une et l'autre espèce il diminue avec l'âge. Il varie de 20·7 à 13·6 chez *M. merluccius* et de 21·2 à 14·2 chez *M. senegalensis*. Le "merlu noir" paraît donc posséder un oeil légèrement plus grand que le "merlu blanc".

II. Caractères méristiques.

Comme l'indiquent les tableaux suivants, ces caractères mettent mieux en évidence que les précédents les différences existant entre les deux espèces.

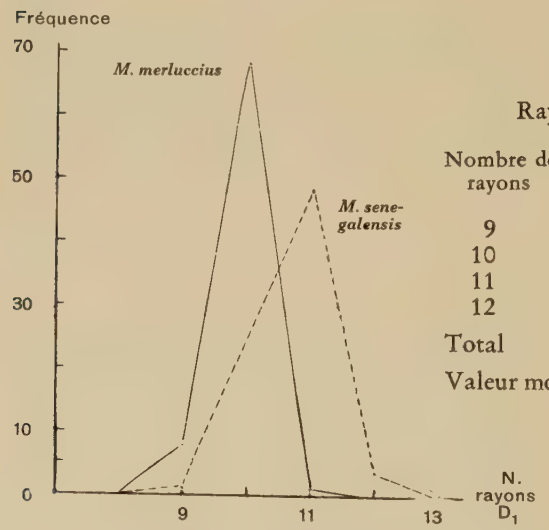


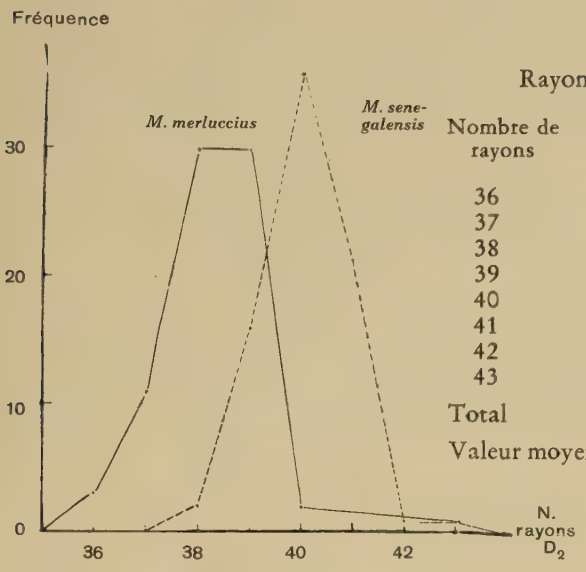
Figure 1. Polygone de variation du nombre de rayons à la 1ère dorsale.

Rayons de la dorsale 1.

Nombre de rayons	Fréquence *M. merluccius*	Fréquence *M. senegalensis*
9	8	1
10	*68*	24
11	1	*48*
12	—	4
Total	*77*	*77*
Valeur moyenne	*9·90*	*10·715*

En résumé:—

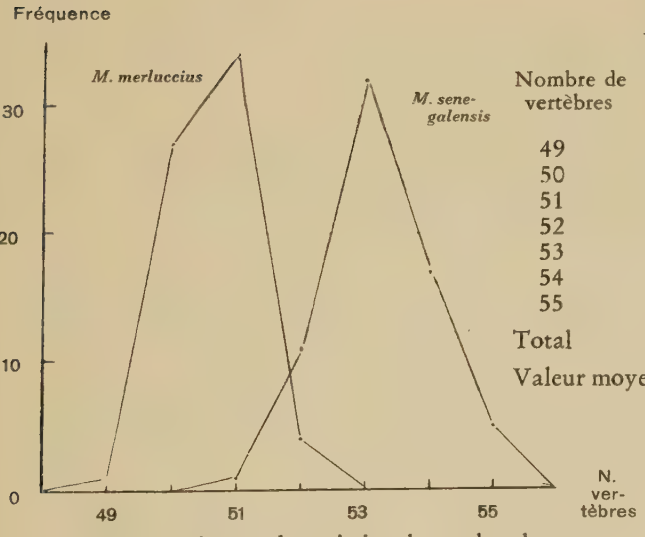
Les caractères métriques (longueur de la tête, distance prédorsale 1, distance préanale, et même diamètre de l'oeil) ne présentent que peu de différence d'une espèce à l'autre et ne sont pas des caractères différentiels suffisamment précis.



Rayons de la dorsale 2.

Nombre de rayons	Fréquence *M. merluccius*	Fréquence *M. senegalensis*
36	3	—
37	11	—
38	*30*	2
39	*30*	16
40	2	*36*
41	—	21
42	—	1
43	1	1
Total	77	77
Valeur moyenne	*38·286*	*40·077*

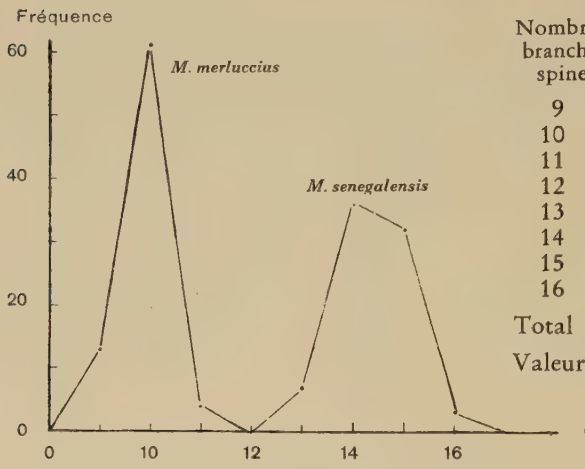
Figure 2. Polygone de variation du nombre de rayons à la 2ème dorsale.



Vertèbres.

Nombre de vertèbres	Fréquence *M. merluccius*	Fréquence *M. senegalensis*
49	1	—
50	27	—
51	*34*	1
52	4	11
53	—	*32*
54	—	17
55	—	5
Total	66	66
Valeur moyenne	*50·622*	*53·212*

Figure 3. Polygone de variation du nombre de vertèbres.



Branchiospines du 1er arc.

Nombre de branchio-spines	Fréquence *M. merluccius*	Fréquence *M. senegalensis*
9	13	—
10	*61*	—
11	4	—
12	—	—
13	—	*7*
14	—	*36*
15	—	32
16	—	3
Total	78	78
Valeur moyenne	*9·885*	*14·397*

Figure 4. Polygone de variation du nombre de branchiospines.

En revanche, les caractères numériques:—

Rayons de la 1ère dorsale (1 de plus en moyenne chez *M. senegalensis*)
„ de la 2ème dorsale (2 „ „ „ „ „ „)
et surtout Vertèbres (3 „ „ „ „ „ „)
et Branchiospines (4 „ „ „ „ „ „)

sont d'excellents caractères spécifiques permettant, dans tous les cas, de séparer *M. merluccius* de *M. senegalensis.*

III. Coloration.

M. merluccius, typique, pêché dans la région de Casablanca a le dos gris foncé, le ventre blanc; ses muqueuses sont peu colorées.

M. senegalensis, typique, pêché dans la région de Port Etienne, par exemple, a le dos noir; le ventre est marqué de pigmentations grises; les muqueuses sont noires.

Notons pourtant que malgré ces différences apparentes, il n'est pas toujours possible de distinguer les deux espèces d'après la coloration, particulièrement dans les régions où elles cohabitent.

Il est même des cas où le "merlu noir" n'est guère plus coloré que le "blanc" et d'autres où ce dernier peut présenter un mélanisme qui, à première vue, le ferait confondre avec *M. senegalensis.* Voici 2 exemples de cette anomalie:—

1. Des merlus de l'espèce *M. senegalensis* pêchés à Casablanca et à Agadir et bien caractérisés par le nombre de leurs vertèbres et de leurs branchiospines avaient le dos gris, le ventre blanc, les muqueuses restant malgré tout noires.
2. Un spécimen de *M. merluccius* pêché dans la région du Cap Draa

présentait l'aspect extérieur d'un "merlu noir", les muqueuses elles-mêmes étant foncées.

Il nous semble donc prudent de ne retenir la pigmentation que comme un caractère secondaire, la diagnose devant s'appuyer d'abord sur les caractères numériques précités.

IV. Répartition géographique.

Ainsi que nous l'avons déjà signalé, l'espèce *M. merluccius* domine largement dans le nord du Maroc. Sur la côte sud (à partir du Cap Ghir) et sur celle du Rio de Oro, les 2 espèces cohabitent; *M. senegalensis* est peut-être le plus abondant, au moins près de la côte. Nous avons pourtant rencontré à Casablanca quelques exemplaires de cette dernière espèce, tandis que nous avons trouvé, dans des lots provenant de Port Etienne (Mauritanie) des spécimens de *M. merluccius*.

Ainsi, sur toute la côte d'Afrique nord-occidentale (du Maroc à la Mauritanie) les deux espèces coexistent et semblent vicariantes.

Données Biométriques sur le Thon Rouge de la Mer du Nord.

Par

C. Nédélec.

Le thon rouge, capturé occasionellement en Mer du Nord par les chalutiers boulonnais, ne fait pas l'objet d'une pêche particulière, mais il arrive assez fréquemment qu'un chalutier débarque à Boulogne une dizaine de thons pesant chacun de 200 à 300 Kg., pêchés à la ligne — le plus souvent — ou au fusil lance-harpon. Les mois les plus favorables sont Juillet, Août, et Septembre comme le montrent les tonnages mensuels pour 1952:—

Juillet	8,860 Kg.
Août	23,960 „
Septembre	11,200 „
Octobre	1,150 „

Matériel étudié: 75 thons de 208 à 260 cm., débarqués à Boulogne pendant la période du 23 Août au 17 Septembre 1952 et capturés sur les lieux de pêche suivants:— Fladen, Gut, Farn Deep, Dogger Bank.

Données biométriques.

1. Méthode.

Les mensurations et les notations employées sont les mêmes que celles de Heldt, Frade et Russell. Les longueurs ont été mesurées à l'aide d'un décamètre-ruban en suivant la courbure du corps; seule la hauteur maxima a été mesurée entre perpendiculaires (voir Figure 1).

2. Résultats obtenus.

Voir le Tableau A où sont portées les moyennes et les limites certaines de la moyenne. Dans cette étude nous avons adopté comme limites certaines de la moyenne (LC) les valeurs:—

$$LC = M \pm 3{\cdot}29\ \sigma_M$$

M = moyenne
σ_M = écart-type de la moyenne

où la probabilité d'obtenir une moyenne égale ou extérieure aux limites certaines est égale à 0·001.

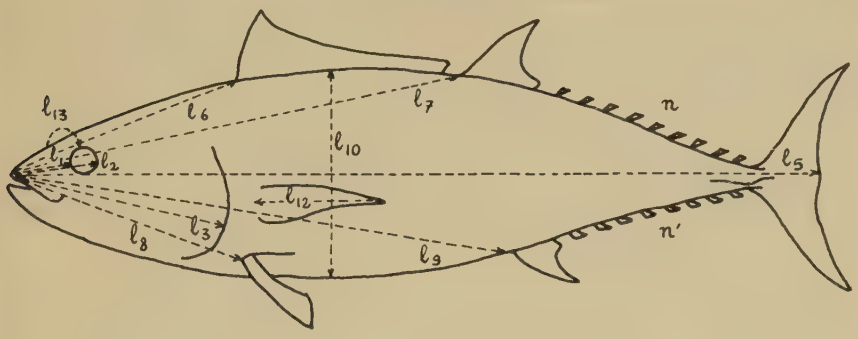


Figure 1. Mensurations effectuées.

Indices calculés:—

$$Oi_1 = \frac{2\,l_3}{l_1 + l_2} \qquad Pi = \frac{l_5}{l_{12}} \qquad D'i = \frac{l_5}{l_7}$$

$$Oi_2 = \frac{l_3}{l_2 - l_1} \qquad Pi/Ti = \frac{l_3}{l_{12}} \qquad Vi = \frac{l_5}{l_8}$$

$$Oi_3 = \frac{l_3}{l_{13}} \qquad Hi = \frac{l_5}{l_{10}} \qquad Ai = \frac{l_5}{l_9}$$

$$Ti = \frac{l_5}{l_3} \qquad Di = \frac{l_5}{l_6}$$

Tableau A. Comparaison des indices biométriques des thons de la Mer du Nord, de l'Algarve, et de la Méditerranée.

Indices	Mer du Nord 1952	Mer du Nord Russell 1933	Algarve Frade G_4	Méditerranée Heldt G_4
Oi_1	M = 2·46	M = 2·42 LC = 2·385—2·455	M = 2·406 2·381—2·430	M = 2·433 2·410—2·456
Oi_2	11·28	11·42 11·079—11·762	9·726 9·231—10·221	10·98 10·42—11·54
Oi_3	1·96 1·927—1·993	—	—	1·82
Ti	3·71 3·654—3·766	3·74 3·681—3·799	3·713 3·658—3·768	3·87 3·81—3·93
Pi	5·58 5·360—5·800	5·57	5·590 5·410—5·770	5·99 5·67—6·31
Pi/Ti	1·51	—	1·491 1·466—1·516	1·516 1·476—1·556
Hi	3·91	—	—	3·81 3·635—3·985
Di	3·65 3·587—3·713	3·62 3·558—3·682	3·555 3·510—3·600	3·518 3·458—3·578
Di'	1·95 1·924—1·976	1·93 1·909—1·951	(1·886) 1·871—1·901	1·887 1·858—1·916
Vi	3·15 3·064—3·236	3·17 3·096—3·244	3·197 3·137—3·257	3·397 3·329—3·465
Ai	1·65	1·64 1·632—1·668	1·660 1·648—1·672	1·657 1·634—1·680

3. Comparaison des résultats avec ceux obtenus en Méditerranée (Groupe 200 à 260 cm. de H e l d t) et en Mer du Nord (Groupe 232 à 271 cm. de R u s s e l l). Voir le Tableau A.

Oi_1. On note des valeurs très variables qui sont dues aux erreurs constantes faites sur les valeurs faibles des espaces pré-orbitaires (20 à 30 cm. mesurés au $^1/_2$ cm. près, soit une précision du $^1/_{50}$, qui est de l'ordre des différences constatées entre les valeurs de cet indice). On ne peut donc pas tenir compte des différences observées.

Oi_2. Pas de différences. La moyenne obtenue, ainsi que celle de R u s s e l l, se place à l'intérieur des limites de la moyenne obtenue en Méditerranée. Même remarque que pour Oi_1, en regard de la valeur faible du diamètre de l'oeil (5 à 6 cm. mesurés au $^1/_2$ cm. près).

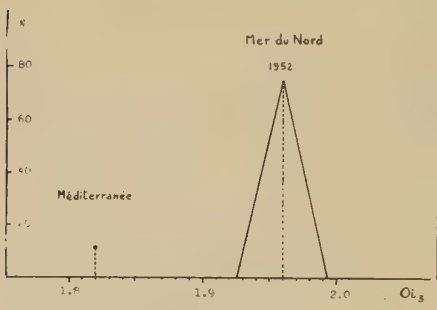


Figure 2.

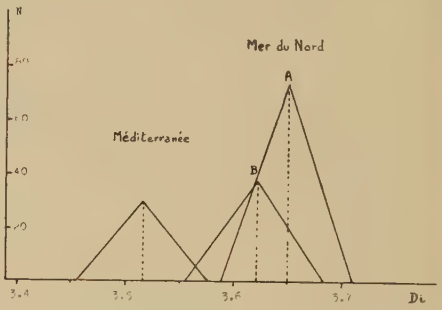


Figure 5.

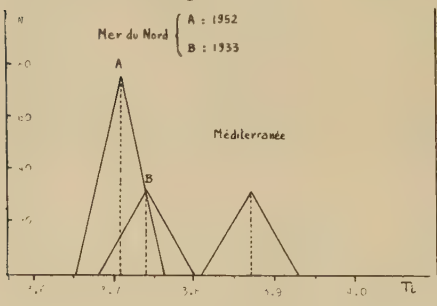


Figure 3.

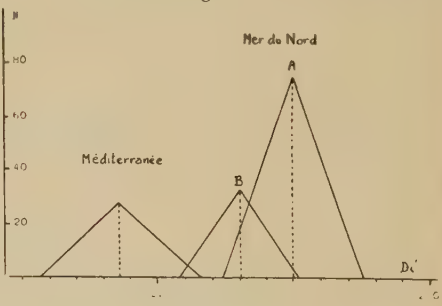


Figure 6.

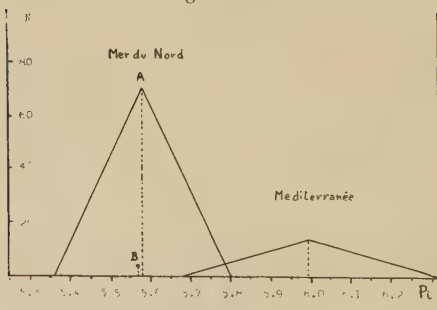


Figure 4.

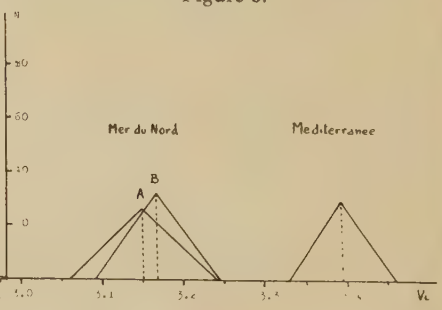


Figure 7.

Oi_3. Ici apparaît une différence. La moyenne obtenue par Heldt est plus faible que la nôtre et se trouve en dehors des limites certaines de notre moyenne. Cependant on ne peut pas conclure d'une façon définitive car la moyenne de Heldt porte seulement sur 11 exemplaires et n'a pas de limites certaines (voir Figure 2). Pas de comparaison possible avec la moyenne de Russell qui porte sur l'espace inter-orbitaire mesuré entre perpendiculaires.

Ti. La moyenne obtenue est plus faible que celle de Heldt et elle est trés voisine de celle de Russell, ce qui élimine la possibilité d'une différence due à des erreurs constantes dans les mesures. Le triangle représentatif de la fluctuation de notre moyenne recouvre le triangle de fluctuation de la moyenne de Russell, mais ces deux triangles sont distincts de celui de la moyenne du thon méditerranéen (voir Figure 3). Le thon de la Mer du Nord a donc la tête plus grande que le thon de la Méditerranée.

Pi. Notre moyenne est inférieure à celle de Heldt. Russell a trouvé une valeur presque identique à la nôtre d'après les mesures de 4 exemplaires seulement. Les triangles de fluctuation des moyennes se recouvrant légèrement (voir Figure 4) nous ne pouvons pas affirmer l'existence de deux valeurs distinctes, mais nous pouvons dire que le thon de la Mer du Nord diffère très probablement du thon méditerranéen par ce caractère et possède donc une pectorale plus longue.

Pi/Ti. Ce rapport est peu différent de celui établi par Heldt mais les 2 indices Pi et Ti sont plus petits en Mer du Nord qu'en Méditerranée.

Hi. Pas de différence. La valeur moyenne obtenue se situe à l'intérieur des limites certaines de la moyenne de Heldt. Pas de comparaison possible avec la moyenne de Russell qui correspond à la hauteur du corps au niveau des pelviennes.

Di. La moyenne, ici, est peu différente de celle de Russell. Toutes les deux sont nettement plus fortes que celle obtenue en Méditerranée. Le nombre plus grand d'exemplaires étudiés nous donne deux valeurs distinctes (voir Figure 5) et nous pouvons dire que, chez le thon de la Mer du Nord, la première dorsale est située plus en avant que chez le thon de la Méditerranée (différence déjà signalée par Russell en 1933).

Di′. Notre moyenne est peu différente de celle de Russell, et toutes les deux sont nettement plus grandes que celle de Heldt. Là aussi, le nombre plus élevé d'exemplaires sépare les deux triangles de fluctuation (voir Figure 6). Donc, chez le thon de la Mer du Nord la 2ème dorsale est située plus en avant que chez le thon méditerranéen (différence signalée également par Russell).

Vi. La moyenne obtenue est identique à celle de Russell. Ces deux moyennes sont plus faibles que celle obtenue pour le thon tunisien. La construction des triangles de fluctuation nous donne 2 valeurs distinctes (voir Figure 7). Sur le thon de la Mer du Nord, l'insertion des ventrales se fait plus en arrière que sur le thon méditerranéen.

Ai. Pas de différences. La moyenne établie est très peu différente de celles obtenues par Russell et par Heldt.

Nombre de pinnules.

a) Nombre de pinnules dorsales (n):—
Fréquences observées:— 3 à 8 pinnules, **51 à 9**, 33 à 10.
On note une certaine différence entre ces résultats et les fréquences observées par Heldt (1 à 8, 7 à 9, **77 à 10**, 4 à 11).

b) Nombre de pinnules ventrales (n'):—
Fréquences observées:— 40 à 8, 47 à 9.
On note, là aussi, une différence entre ces observations et les fréquences observées par Heldt. (5 à 8, 81 à 9, 3 à 10).

c) Fréquences des combinaisons:—
3 à 8/8, **29 à 9/8**, 22 à 9/9, 25 à 10/9, 8 à 10/8.
La combinaison 9/8 domine tandis que Heldt observe surtout en Mediterranée la combinaison 10/9 (60 % des cas).
Remarque:—
Le nombre de pinnules est un caractère difficile à déterminer avec certitude, les premières pinnules étant souvent mal individualisées. On ne doit lui accorder qu'une valeur secondaire.

4. Récapitulation des différences observées entre le thon de la Méditerranée et le thon de la Mer du Nord.

Le thon de la Mer du Nord a:—
la tête plus grande,
la pectorale plus longue,
les deux dorsales plus avancées,
les ventrales situées plus en arrière,
un nombre de pinnules plus faible,
que le thon de la Méditerranée.

Comparaison des thons de Tunisie, de l'Algarve, et de la Mer du Nord. Conclusions.

Nous avons porté également sur le Tableau A les valeurs des indices obtenus par Frade pour les thons de l'Algarve (Portugal) de 200 à 260 cm.

On constate que, mis à part les indices Oi_1 et Oi_2 auxquels d'après nous on ne peut accorder de valeur certaine, le thon de l'Algarve diffère du thon de la Méditerranée par les mêmes indices que le thon de la Mer du Nord (Ti, Pi, Vi), ces indices étant très voisins chez les thons de l'Algarve et de la Mer du Nord. Remarquons cependant la valeur intermédiaire de Di, et celle de Di' analogue à celle de l'indice correspondant du thon tunisien (il est possible que cette différence provienne du fait que Frade a calculé Di' à partir de l'ensemble des groupes de tailles soit 100 à 260 cm. au lieu de 200 à 260 cm.).

Notons également que, de même que le thon de la Mer du Nord, le thon de l'Algarve présente un nombre de pinnules plus faible (combinaison dominante = 9/8) que le thon méditerranéen.

En résumé, d'une part, le thon de l'Algarve a:—

la tête plus grande,
la pectorale plus longue,
la première dorsale légèrement plus avancée (pas de comparaison possible pour la 2ème dorsale),
les ventrales situées plus en arrière,
un nombre de pinnules plus faible,

que le thon tunisien.

D'autre part, le thon de la Mer du Nord a:—

la tête aussi grande,
la pectorale aussi longue,
la première dorsale un peu plus avancée (pas de comparaison possible pour la 2ème dorsale),
les ventrales au même niveau,
un nombre presque identique de pinnules,

que le thon de l'Algarve.

Nous pouvons donc en déduire que le thon de la Mer du Nord se rapproche de celui de l'Algarve, tous les deux différant notablement du thon tunisien par plusieurs caractères.

Ces comparaisons (Mer du Nord 1933 et 1952 — Algarve — Tunis) font apparaître avec plus de certitude l'existence d'une population de l'Atlantique nord-est distincte de la population méditerranéenne.

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Frade. "Données biométriques pour l'étude du thon rouge de l'Algarve". Bull. Soc. Portugaise Sc. Naturelles, **11**, 7, 1931.

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Contribution à l'Etude des Thonidés de l'Atlantique Tropical.

Par

E. Postel,

Section Technique des Pêches Maritimes de l'A. O. F.

En prenant le terme de T h o n i d é s dans sa plus large acception, on rencontre dans l'Atlantique est-tropical neuf espèces appartenant à ce groupe[1]):—

Auxis thazard (Lac.)
Euthynnus alliteratus (Raf.)
Katsuwonus pelamis (L.)
Neothunnus albacora (Lowe)
Parathunnus obesus (Lowe)
Sarda sarda (Bloch)
Orcynopsis unicolor (Geof. St. Hil.)
Cybium tritor (C. V.)
Acanthocybium solandri (C. V.)

Cette dernière espèce est localisée autour des Iles du Cap Vert; les autres fréquentent régulièrement la côte africaine.

J'ai effectué, depuis 1948, des observations d'ordre statistique sur ces différents poissons. Les renseignements relatifs à chaque exemplaire examiné sont consignés sur une fiche, renseignements biométriques au recto, renseignements divers au verso. Le dépouillement de ces fiches amène à des constatations intéressantes.

Dans l'exposé ci-dessous, qui comporte uniquement une brève étude des contenus stomacaux, des parasites, et de quelques rapports pondéraux, quatre espèces, pour lesquelles les observations sont trop peu nombreuses, ont été éliminées (*A. thazard*, 16; *K. pelamis*, 17; *P. obesus*, 1; *A. solandri*, 7).

Contenus stomacaux (voir Tableau 1).

Liste établie après inventaire des estomacs de:—

E. alliteratus	— 513	*O. unicolor*	— 120
N. albacora	— 58	*C. tritor*	— 286
S. sarda	— 588		

---

[1]) J'ai eu l'occasion de voir également à Dakar deux *Thunnus thynnus* (L.) capturés au nord du Cap Blanc.

Tableau 1. Contenus stomacaux.

	N. albacora	*E. alliteratus*	*S. sarda*	*O. unicolor*	*C. tritor*
Poissons.					
Débris indéterminés	×	×	×	×	×
Clupéïdés.					
Sardinella sp.	×	×	×	×	×
Sardinella aurita	×	×	—	—	—
Engraulis sp.	×	×	×	×	×
Aulopidés.					
Aulopus sp.	—	×	—	—	—
Synodidés.					
Saurida parri[1])	—	×	—	—	—
Myctophidés.					
Myctophum sp.	×	×	—	—	—
Exocoetidés.					
Fondiator acutus	×	×	—	—	—
Cypselurus sp.	×	×	—	—	—
Hemiramphidés	×	×	—	—	—
Sphyraenidés.					
Sphyraena sp.	×	×	—	—	—
Mugilidés.					
Mugil sp.	—	—	—	—	×
Polynemidés.					
Galeoïdes polydactylus	—	×	—	—	—
Scombridés.					
Scomber colias	—	×	×	×	—
Auxis thazard	×	×	—	—	—
Euthynnus alliteratus	×	×	—	—	—
Trichiuridés.					
Trichiurus lepturus	×	—	—	—	—
Carangidés[2])					
Decapterus punctatus	×	×	—	×	×
Vomer setipinnis	×	—	—	—	—
Pristopomatidés.	×	—	—	—	—
Sparidés.					
Pagellus sp.	—	×	—	—	—
Sargus sp.	—	×	—	—	—
Box boops	—	×	—	×	—
Maenidés.					
Smaris sp.	—	×	—	—	—
Labridés.					
Coris julis	—	—	—	—	×
Ammodytidés.					
Ammodytes sp.	—	×	×	×	×
Uranoscopidés.					
Uranoscopus sp.	×	—	—	—	—
Balistidés.					
Balistes sp.	×	—	—	—	—
Tetrodontidés.					
Canthigaster rostratus[1])	×	—	—	—	—
Crustacés.					
C. planctoniques	×	×	×	—	—

[1]) Det. J. Cadenat, Dakar.
[2]) Ou *Caranx ronchus* ou *Selar crumenophthalmus.*

Tableau 1. (Suite)

	N. *albacora*	E. *alliteratus*	S. *sarda*	O. *unicolor*	C. *tritor*
Amphipodes.					
Caprelles	—	—	×	—	—
Schizopodes.					
Euphausiacés	—	×	×	—	—
Décapodes.					
Sergestidés	×	—	—	—	—
Parapenaeus longirostris	×	×	—	—	—
Mollusques.					
Mollusques testacés	—	×	—	—	—
Céphalopodes.					
Sepia sp.	×	×	—	—	—
Loligo sp.	×	×	—	—	—
Alloteuthis africana[3])	—	×	—	—	—
Cranchia scabra[3])	×	—	—	—	—
Octopus vulgaris[3])	×	—	—	—	—
Argonauta sp.[3])	×	—	—	—	—
Bryozoaires.	—	×	—	—	—
Madrépores.	—	×	—	—	—
Algues vertes.	—	×	—	—	—

[3]) Det. W. A d a m, Bruxelles.

Les Clupéïdés (toutes saisons) et les Ammodytidés (saison froide) forment la base de l'alimentation des Thonidés.

L'examen des contenus stomacaux situe *S. sarda*, *O. unicolor*, et *C. tritor* comme poissons littoraux. *E. alliteratus* et *N. albacora* vivent plus au large tout en faisant de nombreuses incursions sur le plateau continental, surtout les premiers.

Parasites (voir Tableau 2).

Liste établie après autopsie de:—

E. alliteratus	— 513	*O. unicolor*	— 120
N. albacora	— 58	*C. tritor*	— 286
S. sarda	— 588		

Toutes les déterminations sont dûes au Professeur R. Ph. D o l l f u s.

Les *E. alliteratus* sont de loin les animaux les plus parasités. Des larves de *Callitetrarhynchus* s'agglomèrent dans la cavité générale, à proximité du foie ou des organes génitaux, en amas ayant l'aspect d'une grappe et dépassant parfois la taille du pouce. Aucun des *Euthynnus* examinés n'était indemne.

Rapports pondéraux.

Ils sont indiqués dans des tableaux où les colonnes N et N′ comportent des chiffres qui indiquent le nombre d'exemplaire pris en considération. Les pesées des différents organes ont été effectuées au

Tableau 2. Parasites.

Hôte	Nom, forme, et localisation du parasite
N. albacora	*Dasyrhynchus Talismani* (R. Ph. Dollfus) Larves plerocercus — Intestin.
	Hirudinella sp. — Adulte — Estomac.
	Brachiella thynni — (Cuvier) — Adulte — Branchies.
E. alliteratus	*Callitetrarhynchus gracilis* (Rudolphi) — Larves plerocercus — Cavité générale.
	Otobothriidae — Larves plerocercus. Caeca pyloriques.
	Radinorhynchus pristis (Rudolphi) — Adulte — Estomac.
	Sterrhurus sp. — Adulte — Estomac.
	Hirudinella clavata (Menzies) — Adulte — Estomac.
	Hexostoma thunninae (C. Parona & A. Perugia) — Adulte — Branchies.
	Hexostoma macrocanthum (H. Fujii) — Adulte — Branchies.
	Nerocila Orbignyi (Guérin-Meneville) forma *maculata* (H. M. Edwards) — Adulte — Pinnules ventrales.
S. sarda	*Callitetrarhynchus gracilis* (Rudolphi) — Larves plerocercus — Cavité générale.
	Livoneca sp. — Adulte — Branchies.
O. unicolor	*Callitetrarhynchus gracilis* (Rudolphi) — Larves plerocercus — Cavité générale.
	Nematodes — Larves — Caeca pyloriques.
	Meinertia collaris (Schiödte & Meinert) — Adulte — Pectorale.
	Nerocila Orbignyi (Guérin-Ménevile) forma *maculata* (H. M. Edwards) — Adulte — 2° Dorsale.
	Anilocra sp. — Adulte —Pinnules ventrales.
C. tritor	*Callitetrarhynchus gracilis* (Rudolphi) Larves plerocercus — Cavité générale.

gramme près, celles des poissons entiers arrondies au décigramme. Les résultats sont exprimés en $^0/_0$ du poids total.

Rapports cardiosomatiques (voir Tableau 3).

Afin de diminuer au maximum l'erreur relative, les mesures ont porté sur les plus gros exemplaires de chaque espèce. Les Cybiidés se distinguent par leur rapport particulièrement faible. Aucune différence n'apparaît entre mâles et femelles.

Tableau 3. Rapport cardiosomatique.

Espèce	N	Mâles Max.	Moy.	Min.	N'	Femelles Max.	Moy.	Min.
E. alliteratus	53	0·58	0·43	0·33	42	0·56	0·44	0·37
N. albacora	14	0·30	0·26	0·22	5	0·30	0·26	0·24
S. sarda	13	0·19	0·17	0·12	14	0·21	0·16	0·10
O. unicolor	26	0·21	0·15	0·10	29	0·20	0·15	0·10
C. tritor	10	0·15	0·12	0·08	13	0·15	0·11	0·07

Tableau 4. *Euthynnus alliteratus.*

Mois	N	Rapport gonosomatique Max.	Moy.	Min.	N′	Rapport hépatosomatique Max.	Moy.	Min.
			Mâles					
Janvier	42	1·50	0·38	0·14	26	2·05	1·50	1·12
Février	4	0·59	0·34	0·16	3	2·04	1·53	0·98
Mars	1	0·46	0·46	0·46	0	—	—	—
Avril	16	1·32	0·53	0·13	16	2·64	1·78	1·11
Mai	2	1·11	0·97	0·83	2	2·04	1·77	1·50
Juin	1	2·30	2·30	2·30	1	1·43	1·43	1·43
Juillet	6	4·40	3·60	1·92	0	—	—	—
Août	8	3·50	2·20	1·12	1	1·49	1·49	1·49
Septembre	9	6·50	2·62	1·66	2	1·44	1·11	0·77
Octobre	41	3·96	1·28	0·16	10	2·05	1·24	0·73
Novembre	31	1·70	0·77	0·32	24	1·84	1·18	0·67
Décembre	12	0·61	0·30	0·21	6	1·35	1·25	1·16
			Femelles					
Janvier	52	2·96	1	0·60	27	2·20	1·73	1·21
Février	1	0·61	0·61	0·61	0	—	—	—
Mars	1	1·14	1·14	1·14	0	—	—	—
Avril	10	2·27	1·14	0·74	9	2·20	1·87	1·46
Mai	4	1·68	1·07	0·76	3	2·51	1·75	1·28
Juin	1	0·58	0·58	0·58	1	2·50	2·50	2·50
Juillet	6	4·95	2·67	1·15	1	1·48	1·48	1·48
Août	10	3·98	2·41	1·21	1	1·76	1·76	1·76
Septembre	12	3·36	1·83	0·90	4	1·44	1·21	1·00
Octobre	37	3·66	1·19	0·43	7	1·77	1·30	0·96
Novembre	21	1·33	0·87	0·63	18	1·85	1·24	0·90
Décembre	10	1·21	0·90	0·70	9	1·77	1·45	1·21

Tableau 5. *Neothunnus albacora.*

Mois	N	Rapport gonosomatique Max.	Moy.	Min.	N′	Rapport hépatosomatique Max.	Moy.	Min.
			Mâles					
Mai	5	0·21	0·11	0·05	5	1·27	1·04	0·72
Juin	0	—	—	—	0	—	—	—
Juillet	7	1·33	0·94	0·25	1	1·37	1·37	1·37
Août	5	0·54	0·24	0·03	5	0·85	0·79	0·73
Septembre	2	0·06	0·04	0·03	2	0·67	0·67	0·67
Octobre	1	0·09	0·09	0·09	1	0·88	0·88	0·88
Novembre	0	—	—	—	0	—	—	—
Décembre	3	0·06	0·05	0·03	3	0·85	0·76	0·71
			Femelles					
Août	3	0·41	0·32	0·18	3	0·85	0·81	0·78
Septembre	0	—	—	—	0	—	—	—
Octobre	2	0·38	0·35	0·32	2	0·92	0·84	0·76
Novembre	0	—	—	—	0	—	—	—
Décembre	2	0·56	0·46	0·37	2	1·01	0·99	0·97

Tableau 6. *Sarda sarda.*

Mois	N	Rapport gonosomatique Max.	Moy.	Min.	N′	Rapport hépatosomatique Max.	Moy.	Min.
			Mâles					
Janvier	9	4·66	2·47	1·11	7	1·47	1·25	0·93
Février	3	4·28	2·77	1·20	2	1·25	1·25	1·25
Mars	37	4·60	1·03	e	33	2·92	1·77	0·40
Avril	108	5·42	1·54	e	107	4·30	1·83	0·85
Mai	116	5·31	1·25	e	112	2·55	1·59	0·82
Octobre	3	0·29	0·13	e	2	2	1·72	1·45
Novembre	6	2·70	0·88	0·11	3	1·25	0·92	0·33
Décembre	5	3·77	1·45	e	3	1·60	1·35	1·13
"e" désigne une quantité très petite.								
			Femelles					
Janvier	12	5·90	4·20	1·60	10	2·15	1·75	1·26
Février	3	4·62	2·25	0·83	1	1·43	1·43	1·43
Mars	37	5·32	1·98	0·38	35	3·10	2	1
Avril	74	9·60	2·27	0·35	72	2·93	1·93	0·78
Mai	142	7·65	1·96	0·34	142	3·06	1·82	0·43
Octobre	4	1·15	1	0·94	4	1·90	1·47	1·22
Novembre	3	1·58	1·36	1·12	1	1·13	1·13	1·13
Décembre	6	1·53	1·08	0·31	5	2·43	1·81	1·08

Tableau 7. *Orcynopsis unicolor.*

Mois	N	Rapport gonosomatique Max.	Moy.	Min.	N′	Rapport hépatosomatique Max.	Moy.	Min.
			Mâles					
Janvier	3	0·57	0·31	e	3	1·30	0·96	0·73
Février	2	0·41	0·40	0·38	2	1·07	1·05	1·03
Mars	16	1·11	0·53	0·36	16	2·13	1·38	1·05
Avril	7	2·90	1·38	0·66	7	1·86	1·34	1·02
Mai	3	6·40	3·35	0·39	3	1·56	1·23	0·77
Juin	1	7·60	7·60	7·60	1	1	1	1
Décembre	5	0·45	0·38	0·34	5	1·32	1·10	0·77
"e" désigne une quantité très petite.								
			Femelles					
Janvier	5	1·45	1·13	0·91	5	1·45	1·03	0·74
Février	2	1·05	1	0·94	2	1·01	1	0·98
Mars	21	1·63	1·25	1·02	21	1·78	1·15	0·83
Avril	5	1·97	1·68	1·31	5	1·75	1·45	1·16
Mai	5	7·45	3·30	1·50	5	2·18	1·35	0·88
Décembre	8	1·17	1·05	0·93	8	1·19	0·94	0·75

Rapports gonosomatiques
(voir Tableaux 4, 5, 6, 7, 8).

Etablis sur individus ayant atteint au moins une fois leur maturité sexuelle c'est-à-dire dépassant:—

45 cm. pour *E. alliteratus*
65 „ „ *N. albacora*
40 „ „ *S. sarda*
60 cm. pour *O. unicolor*
50 „ „ *C. tritor*

Tableau 8. *Cybium tritor.*

Mois	N	Rapport gonosomatique Max.	Moy.	Min.	N′	Rapport hépatosomatique Max.	Moy.	Min.
			Mâles					
Janvier	3	1·44	0·84	0·28	3	0·83	0·67	0·41
Février	0	—	—	—	0	—	—	—
Mars	1	0·31	0·31	0·31	1	0·78	0·78	0·78
Avril	9	2·76	1·63	e	9	1·42	1·01	0·86
Mai	6	4·67	2·78	0·39	4	0·82	0·68	0·48
Juin	18	6	4·27	1·94	10	1·55	0·81	0·35
Juillet	15	6·20	4·11	2·22	4	1·25	0·90	0·72
Août	0	—	—	—	0	—	—	—
Septembre	5	3	1·95	0·82	0	—	—	—
Octobre	11	3·70	1·14	0·22	0	—	—	—
Novembre	6	0·89	0·55	0·33	0	—	—	—
Décembre	1	e	e	e	0	—	—	—
			Femelles					
Janvier	18	1·08	0·73	0·10	18	1·09	0·64	0·19
Février	1	0·99	0·99	0·99	1	1·06	1·06	1·06
Mars	3	1·14	0·99	0·91	3	1·07	0·86	0·60
Avril	10	2·32	1·50	0·89	10	1·58	1·12	0·67
Mai	8	5·92	2·06	1·21	7	1·27	1·06	0·71
Juin	50	6·90	4·22	0·66	27	1·49	1·16	0·83
Juillet	25	8·25	3·64	1·33	7	1·66	1·24	0·92
Août	16	6·88	3·30	0·61	0	—	—	—
Septembre	7	5·30	2·51	0·82	0	—	—	—
Octobre	24	2·88	1·16	0·67	0	—	—	—
Novembre	26	1·32	0·95	0·63	0	—	—	—
Décembre	5	0·93	0·82	0·65	4	1·08	0·89	0·72

"e" désigne une quantité très petite.

Un examen rapide des tableaux permet de noter que les périodes de maturité (rapport atteignant de 2·50 à 3 % selon les espèces) s'étendent sur un laps de temps assez considérable, que le volume des glandes génitales mâles et femelles est sensiblement le même, que certaines irrégularités font penser à des populations non-homogènes (composées d'individus soit de races différentes, soit de classes différentes, ce qui pourra être élucidé par une étude biométrique plus approfondie).

E. alliteratus, S. sarda, O. unicolor, et *C. tritor* pondent à proximité du Cap Vert. Les aires de ponte de *N. albacora* sont inconnues.

Rapports hépatosomatiques
(voir Tableaux 4, 5, 6, 7, 8).

Etablis sur les mêmes individus que le précédent. N′ est en général plus faible que N parce que les foies, abimés à l'autopsie (ils sont plus fragiles que les gonades), ont été éliminés. Les variations du rapport hépatosomatique sont en général de même sens que celles du rapport gonosomatique et les foies des femelles plus développés que ceux des mâles.

Il est possible de tirer d'autres conclusions, nombreuses et intéressantes, d'un examen plus détaillé de tous les tableaux, mais un tel travail sortirait du cadre de cet exposé dont l'ambition est avant tout d'apporter des chiffres et des matériaux à ceux qui voudront y réfléchir.

Quatrième Note sur les Sparidés de la Côte Marocaine, *Pagellus erythrinus* Linné et *Pagellus bogaraveo* Brünnich.

Par

R. Coupé,

Institut des Pêches Maritimes du Maroc.

CES deux *Pagellus* ont été étudiés selon la méthode définie dans de précédentes notes et adoptée pour l'ensemble des Sparidés du Maroc.

Ces deux espèces, dont les jeunes se ressemblent beaucoup, se différencient en vieillissant.

C'est pour suivre leurs variations morphologiques et rechercher les caractères permettant de les séparer sûrement qu'a été faite cette étude comparative.

I. Caractères morphologiques.

1. Taille.

Pagellus erythrinus atteint fréquemment la taille de 50 cm. tandis que *Pagellus bogaraveo* n'arrive que rarement à 35 cm.

Les spécimens examinés se répartissent ainsi:—

Groupes de Taille en cm.	Fréquence *P. erythrinus*	*P. bogaraveo*
de 2·5 à 7·4	6	—
de 7·5 à 12·4	26	19
de 12·5 à 17·4	—	2
de 17·5 à 22·4	21	41
de 22·5 à 27·4	24	37
de 27·5 à 32·4	11	14
de 32·5 à 37·4	6	3
de 37·5 à 42·4	5	—
	99	116

2. Proportions du corps (voir les 2 tableaux en annexe).

Chez l'une et l'autre des espèces:—

a) Certaines proportions augmentent avec la taille (donc avec l'âge) telles sont: la hauteur du corps, les distances pré-orbitaire et sous-orbitaire, la longueur relative de la pectorale.

Tableau 1. Valeur moyenne des indices en fonction de la taille pour *Pagellus erythrinus*.

Indices	Valeur moyenne des indices répartie par groupe de taille						
	5 cm.	10 cm.	20 cm.	25 cm.	30 cm.	35 cm.	40 cm.
100 Ht. C. / L.T.	26·000	27·120	27·571	27·654	28·099	28·500	29·200
100 T. / L.T.	28·333	26·307	25·190	24·792	24·099	24·333	24·800
100 Post. O. / L.T.	19·000	17·847	17·428	17·041	16·637	16·500	16·400
100 Pr. O. / L.T.	9·666	9·192	10·000	10·208	10·272	10·833	11·000
100 —O. / L.T.	9·666	8·538	7·476	6·834	6·181	5·666	5·600
100 I. O. / L.T.	7·333	7·040	6·523	6·834	6·546	6·500	6·800
100 S. O. / L.T.	4·333	4·230	5·000	5·125	5·272	5·833	5·800
100 Max. / L.T.	9·666	9·307	9·141	9·166	9·181	9·333	9·200
100 M. inf. / L.T.	11·333	10·959	10·709	10·773	9·363	9·333	9·200
100 Pr. D. I. / L.T.	33·834	31·769	31·363	31·291	30·727	30·500	30·666
100 Pr. V. / L.T.	31·666	30·769	30·040	29·043	29·728	30·000	31·000
100 Pr. An. / L.T.	49·834	48·333	47·904	47·917	47·090	47·833	46·600
100 B. Dors. / L.T.	38·166	39·384	39·363	38·917	38·636	39·666	39·400
100 B. An. / L.T.	16·000	15·847	15·181	15·086	14·819	14·833	15·200
100 L. Pect. / L.T.	23·834	24·000	28·000	28·584	28·100	27·000	26·400
100 L. Vent. / L.T.	17·833	16·847	16·409	16·409	16·300	16·000	15·800
100 Ht. Dors. / L.T.	11·333	10·115	10·000	10·262	10·600	10·800	10·800
100 P. Caud. / L.T.	7·500	7·384	6·953	7·125	6·800	7·000	6·600

b) D'autres diminuent: longueur relative de la tête, distance post-orbitaire, diamètre de l'oeil, longueur relative de la mâchoire inférieure, distance préanale.

c) D'autres enfin ne varient pratiquement pas: espace interorbitaire, longueur relative du maxillaire, distance prédorsale et préventrale, base de la dorsale, longueur relative de la ventrale, hauteur de la dorsale et du pédoncule caudal.

Tableau 2. Valeur moyenne des indices en fonction de la taille pour *Pagellus bogaraveo*.

Indices	Valeur moyenne des indices répartie par groupe de taille					
	10 cm.	15 cm.	20 cm.	25 cm.	30 cm.	35 cm.
100 Ht. C. / L.T.	26·790	26·500	28·121	28·162	29·153	30·333
100 T. / L.T.	26·368	25·500	24·693	24·243	24·000	24·333
100 Post. O. / L.T.	16·736	16·500	16·097	15·459	15·066	15·333
100 Pr. O. / L.T.	8·368	8·500	8·902	8·703	8·858	9·660
100 —O. / L.T.	8·313	8·500	7·121	6·784	6·428	6·000
100 I. O. / L.T.	7·210	7·000	7·024	6·973	6·924	6·333
100 S. O. / L.T.	3·790	4·000	4·081	4·027	4·214	4·666
100 Max. / L.T.	8·895	8·500	8·903	8·649	8·858	9·333
100 M. inf. / L.T.	10·105	9·500	9·527	9·353	9·307	9·000
100 Pr. D. I. / L.T.	31·105	29·500	30·414	29·892	30·071	30·333
100 Pr. V. / L.T.	30·263	30·500	29·737	29·892	29·357	30·333
100 Pr. An. / L.T.	47·889	47·500	47·683	47·135	47·000	47·000
100 B. Dors. / L.T.	39·631	40·000	40·024	39·892	40·285	41·000
100 B. An. / L.T.	18·052	17·500	17·659	17·865	17·948	17·666
100 L. Pect. / L.T.	24·473	28·000	27·305	27·272	27·470	28·000
100 L. Vent. / L.T.	17·578	17·500	17·219	17·285	17·071	18·000
100 Ht. Dors. / L.T.	11·000	10·000	11·157	11·648	12·181	13·000
100 P. Caud. / L.T.	7·105	6·500	6·950	6·919	6·929	7·333

Si ces caractères métriques assez peu différents d'une espèce à l'autre ne sont guère utilisables il y a néanmoins une exception. En effet, *dans tous les cas, la base de la nageoire anale est plus grande que la distance post-orbitaire chez les* P. erythrinus *et plus petite chez les* P. bogaraveo. Donc ce rapport, valable pour les jeunes comme pour les adultes, est un excellent caractère différentiel des deux espèces.

D'autre part, si pour ces deux pagels, les variations d'un caractère sont toujours de même sens, elles ne sont pas toujours de même amplitude d'où certaines différences permettant de séparer les adultes. Les plus typiques de ces variations intéressent le diamètre de l'oeil, les distances sous-orbitaire et pré-orbitaire.

Taille en cm.	Nombre de fois que le diamètre de l'oeil contient la distance sous-orbitaire		Nombre de fois que le diamètre de l'oeil est contenu dans la distance pré-orbitaire	
	P. erythrinus	*P. bogaraveo*	*P. erythrinus*	*P. bogaraveo*
5	2·2	—	1	—
10	2·0	2·2	1·1	1·0
15	—	2·1	—	1·0
20	1·5	1·7	1·3	1·3
25	1·3	1·7	1·5	1·3
30	1·2	1·5	1·7	1·4
35	1·0	1·4	1·9	1·6
40	1·0	—	2·0	—

a) Le rapport $\frac{\text{Diamètre de l'oeil}}{\text{Distance sous-orbitaire}}$ de même valeur aux stades jeunes des deux pagels diminue pour les adultes, plus rapidement chez *P. erythrinus* que chez *P. bogaraveo*. Il en résulte que le sous-orbitaire est égal au diamètre de l'oeil chez *P. erythrinus* de 35 à 40 cm. et très inférieur à ce diamètre chez les *P. bogaraveo* de 35 cm.

b) Le rapport $\frac{\text{Distance pré-orbitaire}}{\text{Diamètre de l'oeil}}$ de même valeur pour les jeunes des deux espèces augmente ensuite et plus vite chez *P. erythrinus* que chez *P. bogaraveo*. Le diamètre de l'oeil est alors contenu deux fois dans la distance pré-orbitaire du premier lorsqu'il atteint 40 cm. et environ une fois et demie seulement chez *P. bogaraveo* de 35 cm.

II. Caractères méristiques.

1. Formule vertébrale:—

Pour les deux pagels considérés elle est la même dans tous les cas et égale à 23 vertèbres + 1 (urostyle).

2. Formules radiaires des nageoires:—

a) Dorsale:—

Rayons	Fréquence *P. erythrinus*	Fréquence *P. bogaraveo*
XI — 10+1	1	0
XI — 11+1	0	1
XII — 9+1	1	3
XII — 10+1	*93*	*102*
XII — 11+1	4	7
XIII — 9+1	0	1
XIII — 10+1	0	1
	99	115

b) Ventrales:—

Dans tous les cas on a 1 + 5 rayons pour l'une ou l'autre des deux espèces.

c) Anale:—

Rayons	Fréquence *P. erythrinus*	Fréquence *P. bogaraveo*
III — 9+1	*96*	6
III — 10+1	1	*106*
III — 11+1	—	2

d) Pectorales:—

Rayons	Fréquence			
	P. erythrinus Pectorale		*P. bogaraveo* Pectorale	
	gauche	droite	gauche	droite
14	4	4	1	—
15	72	70	10	12
16	12	13	*92*	*93*
17	—	1	12	10
moyenne par pectorale	15·090	15·125	16·000	15·983
moyenne pour les deux pectorales.	*15·110*		*15·992*	

Ainsi il n'existe aucune différence pour la ventrale et pas de différence sensible pour la dorsale.

En revanche on constate la présence d'un rayon mou de plus pour l'anale et généralement d'un rayon de plus pour la pectorale chez *P. bogaraveo.*

III. En résumé.

Cette note provisoire sur *P. erythrinus* et *P. bogaraveo* permet de constater que:—

1. Les jeunes des deux espèces morphologiquement très semblables peuvent être néanmoins facilement séparés

a) par la base de l'anale plus longue que le post-orbitaire pour *P. bogaraveo* et plus petite pour *P. erythrinus,*

b) par le nombre des rayons des pectorales et de l'anale.

2. Les adultes sont plus différenciés notamment en ce qui concerne les rapports entre le diamètre de l'oeil et la distance sous-orbitaire d'une part, entre le pré-orbitaire et le diamètre de l'oeil d'autre part.

Letter to the Editor.

Antarctic Division,
Department of External Affairs,
187 Collins Street,
Melbourne, Victoria.
6th October 1953.

To the Editor, Journal du Conseil.

Dear Sir.

S h e a r d has shown in "Net Plankton Determination" (*B. A. N. Z. A. R. E. Reports*, Vol. 6, Pt. 1, 1947) that volume measurements of plankton allowed to settle in a graduated cylinder are quite inaccurate. He described and tested a technique of obtaining plankton volumes by a displacement method, in which a known volume of plankton and liquid was filtered, the original container being washed out with known volumes of water. The volume of the filtrate was measured and subtracted from the original total volume to give the volume of plankton.

The new method is based on the displacement principle, but a simpler technique is used. A plain glass tube some 40 cm. long with an external diameter of 3 cm. is used in conjunction with a 250 ml. graduated cylinder of internal diameter slightly less than 3·5 cm. Silk gauze, finer than that used in the net which took the samples, is tied over one end of the plain glass tube. Before plankton volumes can be measured the difference in volume caused by the presence of the tube inside the graduated cylinder must be determined. It is a simple matter to make a graph showing this difference by plotting the readings given by several different volumes of water in the cylinder with the tube in position and without. There is an obvious linear relationship.

The sample to be measured is poured into the glass tube. When most of the water has drained away, air is blown through until water ceases dripping from the tube. The tube and plankton sample are then plunged into the cylinder containing 100 ml. of water. When the plankton is well mixed with water and no bubbles remain, a reading is taken of the level *inside* the tube. The linear graph is used to find the real increase in volume, which approximately equals the volume of the plankton sample. The tube is removed from the cylinder and drained for a few seconds before the compact mass of plankton in the bottom is allowed to slide out of the tube and back into the original container. The whole process can be carried out in six minutes.

Yours faithfully,

E. H. M. Ealey.

Reviews.

J. Bourcart. "Les Frontières de l'Océan." 317 pp., 77 figs. Albin Michel, Paris, 1952.

This is an interesting book. As its name implies, it is concerned with the ocean margins — but they are treated mainly from the point of view of the student of oceanography and shore processes rather than from the "terrestrial" approach, although the author discusses at some length a flexure, the hinge line of which runs inland and more or less parallel to coasts. The nature and mechanism of this structure needs further demonstration although it is invoked in explanation of various phenomena. No distinction is made between estuary and ria, and the transverse nature of the whole of the Atlantic coasts seems to be accepted without further comment. Incidentally *Spartina townsendii* is a natural hybrid and not an American species.

Professor Bourcart deals fully with the various forms of erosion and accumulation along coasts, and is particularly interested in the ways in which material is transported. The reader will find much of value in this section of the book. It is, however, a pity that explanations and discussions are not sometimes fuller. Figure 40 — "Accumulation de sable près d'un épi, d'une jetée" — appears, with the associated text, to emphasize current action too much at the expense of beach-drifting simply by wave action. Elsewhere the author refers to breaking waves giving place to waves of translation which pass imperceptibly into the swash. Waves of translation thus appear to be accepted, but their occurrence is not demonstrated in any way. (Page 79.) Brevity is carried to an extreme in the notice given to beach cusps. To say that Figure 51, a line drawing showing cusps on a beach, "indique le mécanisme probable de formation" is equivalent to saying that a picture of a motor car explains how it goes!

Whilst it is not difficult to criticize this book in detail, it is important to emphasize that it is readable, informative, and interesting. It deals with many important subjects which are only too often missed in other books, and it will give the general reader, for whom it is mainly intended, a good introduction to coastal problems. Nevertheless it bears somewhat the imprint of hasty compilation. Minor errors of spelling of place names occur, and some examples or diagrams might have been chosen with greater care, and from original papers. Some of the maps are not well reproduced. A fuller bibliography would have been advantageous — to refer to the lists of publications given in the works of Sverdrup, Kuenen, and Shepard is not very helpful to the general reader who needs guidance in any further reading he may do. The specialist, on the other hand, will be familiar with these works, but may regret that the author has not made use of — in so far as

this particular volume is concerned — a wider selection than those noticed on page 317.

The book is dedicated to those who during the war undertook work on beach and offshore profiles preparatory to the landings in France and elsewhere for the final liberation. The investigations of W. W. Williams are frequently quoted. Attention is also called to the work of the Beach Erosion Board in America. Unfortunately the statement that "En Angleterre, depuis longtemps, si les travaux se font aux frais des propriétaires et, dans le seul cas d'intérêt général, des collectivités, l'étude technique est entreprise par une Commission Royale" is misleading. There has been but one Royal Commission on Coast Erosion, which issued its final report as long ago as 1911.

J. A. Steers.

E. Gödecke. "Das Verhalten der Oberflächentemperatur in der Deutschen Bucht während der Jahre 1872—1950 und der Zusammenhang mit dem der Nordwest-Europäischen Meere". Ber. Deutschen Wiss. Komm. Meeresf., N. F., **13**, 1, pp. 1—31, 8 figs. Stuttgart, 1952.

This paper is valuable because of its conveniently arranged tables and graphs indicating the anomalies of monthly and yearly temperature averages for each month or year, relative to the corresponding average temperature for the "standard climatological period" 1901—1930. Special attention has been paid to the temperature curve for Helgoland Reede for the period 1872 to 1950.

Gödecke also considers some series of temperature observations from the lightvessels in the Deutsche Bucht, together with similar series from the lightvessels "Terschellingerbank" and "Smith's Knoll". In addition, he uses temperature data from five Norwegian coastal stations, and from Danish ships in the northern part of the North Sea and the Norwegian Sea.

To make his graph more intelligible, Gödecke uses, not the anomalies themselves as a function of time, but the algebraic sum of the anomalies from the beginning of the observations up to the time considered. In this way one can easily see whether the water temperature tends to increase or decrease. It appears that in the North Sea as a whole, as well as in the Norwegian Sea, the water has become warmer during the last 2 or 3 decades. For example, for Helgoland Reede Gödecke found that the period from 1872 to 1950 can be divided into the following parts:—

(1) 1872—1891, with large anomalies from the yearly averages, alternately positive and negative;
(2) 1892—1914, with only small fluctuations of mean temperature;
(3) 1915—1950, with fluctuations still larger than those of the first period, and with positive anomalies predominating on the whole.

From further consideration it appears that the increase in the yearly mean temperatures in the third period are due mainly to large positive anomalies during the summer months, especially September. The month of March, on the whole, became colder.

Within the region considered by Gödecke, the seas between Iceland and Scotland and the Deutsche Bucht seem to show the largest temperature increase, from which Gödecke concludes that in general the heating is of polar or subpolar origin, while the heating of the water along the coast of the Deutsche Bucht is of continental origin. But, as Gödecke himself states, this is only a suggestion, which ought to be more thoroughly studied

in connexion with the pattern of surface currents and meteorological conditions. It is indeed not clear, in view of the above-mentioned suggestion, why, for instance, the temperature increase at Ona is less than it is both north and south of Ona (off the west Norwegian coast). Perhaps the Atlantic current has something to do with this; if so, it would be advisable to study the long-period intensity variations of the Gulf Stream, off Florida for instance, and correlate these variations with the temperature variations in the Norwegian and North Seas.

As to the amount of the temperature increase, G ö d e c k e finds that for Helgoland the increase of mean temperature for the period 1931—1950, with respect to the period 1901—1930, is +0·40°C., as far as the temperature averages over a whole year are concerned. If one considers only the month of September, it appears that the temperature increase for the same period as above amounts to 0·96°C., whereas the month of March has become colder. Thus the thermal range between summer and winter seems to have increased.

M. P. H. Weenink.

N. G. Jerlov. "Optical Studies of Ocean Water." Rep. Swedish Deep-Sea Exped. 1947—8, **3**. Phys. & Chem., No. 1, pp. 1—59, 51 figs. Göteborg, 1951.

N. G. Jerlov and **F. Koczy.** "Photographic Measurements of Daylight in Deep Water." Ibid., No. 2, pp. 61—69, 10 figs. Göteborg, 1951.

Die Meeresoptik ist seit langem ein bevorzugtes Arbeitsgebiet schwedischer Ozeanographen. H. P e t t e r s s o n, der wissenschaftliche Leiter der Schwedischen Tiefsee-Expedition, und seine Mitarbeiter, insbesondere N. G. J e r l o v (J o h n s o n) haben seit zwei Jahrzehnten entscheidend dazu beigetragen, dass sich aus vereinzelten optischen Messungen ein den anderen ozeanographischen Disziplinen gleichwertiges Wissensgebiet wachsender Bedeutung entwickelt hat. Es entsprach somit der Tradition des Göteborger Ozeanographischen Institutes, meeresoptische Messungen in das Expeditionsprogramm aufzunehmen, obgleich dieses vorwiegend dem Meeresboden und den bodennahen Wasserschichten gewidmet war. Der Entschluss, die in Bornö Station gesammelten Erfahrungen für eine umfassende Untersuchung der "Optik der Ozeane" zu verwerten, ist durch die vorliegenden Ergebnisse voll gerechtfertigt worden. Unsere bisherigen Kenntnisse über die Taglicht- und Trübungsverhältnisse in den Ozeanen beruhten auf vereinzelten, von verschiedenen Forschern mit unterschiedlichen Geräten und Methoden durchgeführten Messreihen, die zu teilweise widersprechenden Anschauungen führten. Nunmehr liegen aus den drei Ozeanen untereinander vergleichbare Messungen vor, die mit grosser Sorgfalt nach den gleichen Gesichtspunkten mit denselben Geräten von einem erfahrenen Fachmann durchgeführt, kritisch bearbeitet und in einer den Physiker, Hydrographen und Biologen in gleicher Weise ansprechenden Form dargestellt wurden. Dadurch sind unsere Kenntnisse auf diesem Gebiet teils gefestigt, teils verbessert, vor allem aber wesentlich erweitert worden.

In Report Nr. 1 berichtet N. G. J e r l o v nach einem kurzen historischen Rückblick über die Taglicht- und Durchsichtigkeitsmessungen, die auf 42 über den gesamten Reiseweg der "Albatross" verteilten Stationen bis zu einer maximalen Tiefe von 220 m. durchgeführt wurden. Von den Ergebnissen können hier nur die wichtigsten hervorgehoben werden.

Zunächst befasst sich der Bericht mit den Messungen des sichtbaren Tageslichts (350 bis 700 mμ) unter Wasser, die mit geeichten elektrischen Photometern der bekannten Bauart in verschiedenen Spektralbereichen zum Teil

nach der Differenzmethode durchgeführt wurden. Auf 8 Stationen, die sowohl extrem klares Wasser (östliches Mittelmeer) als auch verhältnismässig trübes Wasser (Caribisches Meer) umfassen, wurde die spektrale Energieverteilung des Oberlichts in verschiedenen Tiefen gemessen. Die Ergebnisse sind sowohl als spektrale Energiekurvenscharen (g. cal./cm.^{2}/min.), als auch in der üblichen logarithmischen Diagrammform der prozentualen Lichtabnahme mit der Tiefe für Wellenlängen in 25 mμ Abstand dargestellt. Sehen wir zunächst von den Absolutwerten ab, so entspricht der asymmetrische Verlauf der Energiekurven und die Verschiebung der Maximalwerte nach kurzen Wellenlängen (bis zu 470 mμ) im wesentlichen unseren bisherigen Vorstellungen. Bemerkenswert ist, dass in 200 m. Tiefe nur noch Licht in einem Spektralbereich zwischen 430 und 500 mμ festgestellt werden konnte. Aus der zweiten Darstellungsart ergibt sich jedoch ein wichtiges neues Ergebnis. Die vertikale Extinktion des kurzwelligen Tageslichts nimmt in klarem und optisch homogenem Wasser mit der Tiefe zunächst zu und bleibt erst von etwa 50 bis 70 m. ab praktisch konstant. Le Grand hat als erster darauf hingewiesen, dass ein solches Verhalten theoretisch durch die Streuung verursacht werden muss. Die Jerlov'schen Messungen bestätigen die Theorie und zeigen andrerseits, dass dieser Effekt nur im kurzwelligen Spektralbereich ($<$500 mμ) und nur in sehr klarem Wasser auftritt, in küstennahen Gebieten also sicher vernachlässigt werden kann.

An Hand der Kurven für den vertikalen Extinktionskoeffizienten für λ = 465 mμ, der infolge der fehlenden Schwerpunktsverschiebung besonders zuverlässig gemessen werden kann, vergleicht der Verfasser die einzelnen Stationen und Meeresgebiete und findet übereinstimmend mit älteren Messergebnissen das klarste Wasser im Sargassomeer und im östlichen Mittelmeer, verhältnismässig trübes Wasser in den südamerikanischen und afrikanischen Auftriebswassergebieten. Die tropischen Meeresgebiete unterscheiden sich nur wenig in der Lichtdurchlässigkeit.

Nicht bestätigt dagegen werden die hohen Extinktionen, die Powell und Clarke unmittelbar unter der Oberfläche gemessen und Luftblasen zugeschrieben hatten. Diese Werte lassen sich als messtechnische Effekte nachweisen.

Als eines der wichtigsten Ergebnisse möchten wir die neuen Werte über die Lichtdurchlässigkeit des Meerwassers im ultravioletten Spektralbereich ansehen. Gerade hier differieren die bisherigen Angaben ausserordentlich stark. Jerlov hat sowohl die UVB-Strahlung (280 bis 315 mμ) mit einem von ihm entwickelten und ausführlich beschriebenen Spezialphotometer als auch die UVA-Strahlung (315 bis 400 mμ) und das anschliessende Blau mit einem normalen Photometer sehr sorgfältig gemessen. Es ergibt sich in klarstem Wasser für die UVB-Strahlung die überraschend hohe Durchlässigkeit von 86 %/m., die für die UVA-Strahlung auf 97 %/m. und für blaues Licht (465 mμ) auf 98 %/m. ansteigt. Diese Ergebnisse sind nicht nur physikalisch, sondern vor allem auch biologisch von ausserordentlicher Bedeutung, besagen sie doch, dass die durch die UV-Strahlung aktivierte Schicht wesentlich tiefer reicht als bisher angenommen wurde. Allerdings bleibt zu berücksichtigen, dass die geringste Trübung und Spuren von Gelbstoff die Durchlässigkeit sehr stark herabsetzt.

Im folgenden Teil des Berichtes befasst sich der Verfasser mit der Winkelverteilung des Tageslichts unter Wasser, die ebenfalls für mehrere Spektralbereiche und verschiedene Tiefen gemessen wurde. Aus diesem Abschnitt sind besonders die Messungen des Unterlichts und der diffusen Reflexion (Verhältnis von Unter- zu Oberlicht) hervorzuheben. Erstere sind wieder in

Form spektraler Energiekurven für verschiedene Tiefen, letztere in Tabellenform angegeben. In klarstem Wasser liegt das Maximum der diffusen Reflexion bei etwa 425 mμ, also gegen das Durchlässigkeitsmaximum (470 mμ) verschoben, was leicht als Folge der selektiven Streuung verstanden werden kann. Messungen der Horizontalbeleuchtung sowie der Richtungsverteilung von 15 zu 15° in einer horizontalen und vertikalen Ebene ergänzen die Unterlichtmessungen und geben mit diesen zusammen einen Einblick in die mittlere Richtungsverteilung des Tageslichtstroms, die, wie Poole zuerst vermutet hat, mit wachsender Tiefe einem Gleichgewichtszustand zustrebt, der nach Jerlov in klarstem Wasser erst in etwa 30 m. Tiefe, bei trüberem Wasser jedoch in wesentlich geringerer Tiefe erreicht wird. Praktisch dürfte auch für klares Wasser die Annahme einer geringeren Grenztiefe genügen, da sich eine wesentliche Änderung der mittleren Richtungsverteilung sowohl im vertikalen Extinktionskoeffizienten als auch besonders in dem Verhältnis von Ober- zu Unterlicht bemerkbar machen müsste.

Die Messungen sind fast ausschliesslich bei gutem Wetter, also Sonnenschein und blauem Himmel durchgeführt. Der Einfluss der Sonnenhöhe auf die Messwerte wird allgemein diskutiert und die mittlere Weglänge zur Reduktion der Messwerte auf einen Normalsonnenstand berechnet. Leider liegen keine Messungen bei bedecktem Himmel vor. So bleiben die Fragen, inwieweit die Einstrahlungsverhältnisse in klarstem Wasser den oben erwähnten Effekt der Zunahme des vertikalen Extinktionskoeffizienten mit der Tiefe für kurze Wellenlängen und die Erreichung des Gleichgewichtszustandes in der Richtungsverteilung (beide Effekte hängen übrigens zusammen!) beeinflussen, vorläufig offen.

Zwei Abschnitte sind der Gelbstoffverteilung und der Farbe des Meerwassers gewidmet, durch die die Arbeiten von Kalle ergänzt werden. Ein Vergleich zwischen der Extinktion des blauen Lichts in den oberen 50 m. und dem Streulicht von Tyndall-Messungen zeigt, dass in klarstem Ozeanwasser kein Gelbstoff vorhanden ist, mit zunehmender Teilchenzahl der Gelbstoffgehalt jedoch rasch wächst und seine Maximalwerte in den Auftriebswassergebieten erreicht.

Besonderes Gewicht kommt den Durchsichtigkeitsmessungen zu, da sie den physikalischen Extinktionskoeffizienten (Summe von Absorption und Streuung) und somit zusammen mit Ober- und Unterlichtmessungen die Möglichkeit zur Extinktionsanalyse ergeben. Jerlov findet, dass im Ozean die Streuung durch Teilchen die Absorption durch Teilchen und gelöste Stoffe überwiegt. Die Streuung an Teilchen zeigt sich als spektral unabhängig und ist hauptsächlich nach vorn gerichtet. Dies deutet auf verhältnismässig grosse Partikel ($>3\ \mu$). Der Verfasser unterscheidet zwischen der selektiven Streuung des Wassers selbst und der nichtselektiven Teilchenstreuung und stellt in 2 Tabellen für klares und trübes Ozeanwasser den physikalischen und vertikalen Extinktionskoeffizienten mit den durch die Teilchen verursachten Streuungs- und Absorptionswerten zusammen.

Ein besonderer Abschnitt ist der maximalen in natürlichen Gewässern auftretenden Durchlässigkeit für Tageslicht gewidmet. Ein Diagramm gibt für die Wellenlängen zwischen 300 und 700 mμ die Tiefen an, in denen die Lichtintensität noch 10 % und 1 % des Oberflächenwertes beträgt. Im Gebiet maximaler Durchlässigkeit liegen diese Tiefen bei 90 bis 140 m. In einer Tabelle sind die Durchlässigkeitswerte für den gleichen Spektralbereich in Abständen von 25 mμ zusammengestellt und mit den entsprechenden Labormessungen an doppelt destilliertem Wasser von Clarke und James verglichen. Die Durchlässigkeit des Ozeanwassers für Tageslicht ist im ultra-

violetten Spektralbereich grösser als die für gerichtetes Licht in doppelt destilliertem Wasser, eine Folge der unterschiedlichen Extinktion eines Lichtstromes und eines Lichtstrahles durch die Streuung. Praktisch zeigen sich destilliertes Wasser und klares Ozeanwasser innerhalb des sichtbaren Spektrums als optisch gleichwertig.

Die letzten beiden Abschnitte befassen sich mit der optischen Klassifikation von Seewasser und der Totalstrahlung im Meere. In den Normaldurchlässigkeitskurven für 3 verschiedene Typen von Ozeanwasser und 9 verschiedene Typen von Küstenwasser (hierzu wurden die bereits früher von Jerlov und Kullenberg veröffentlichten Werte neu berechnet), sowie in der entsprechenden Darstellung für das UV-Gebiet können wir eine Zusammenfassung der zuverlässigsten Tageslichtmessungen im Ozean und in den Küstengebieten sehen. Für die gleichen Normalwassertypen berechnet der Verfasser aus den spektralen Energiekurven die Gesamtenergie in verschiedenen Tiefen. Die Ergebnisse, die sowohl in Diagrammen als auch in Tabellen angegeben sind, dürften für alle Untersuchungen, in denen es vorwiegend auf Mittelwerte ankommt (z. B. Wärmehaushalt, Klimatologie, Biologie) von besonderem Wert sein.

Zusammenfassend lässt sich sagen, dass die "Optical Studies of Ocean Waters" von N. G. Jerlov nicht nur unsere Kenntnisse über die regionalen Extinktionsverhältnisse erweitert haben, sondern vor allem — und darin sehen wir den besonderen Wert der Arbeit — grundsätzliche physikalische Fragen, wie die Lichtdurchlässigkeit des klarsten natürlichen Wassers und die Tageslichtextinktion im sichtbaren und unsichtbaren ultravioletten Spektralbereich weitgehend geklärt haben. Die "andere Seite" der Meeresoptik, die Untersuchungen in trüben Küstengewässern, können nun mit dem beruhigenden Wissen um eine sichere Bezugsbasis fortgesetzt werden.

In Report Nr. 2 berichten N. G. Jerlov und F. Koczy über die photographische Messung des Tageslichts in tiefem Wasser. Hierfür wurden seit jeher photographische Methoden bevorzugt, da die Anwendung photoelektrischer Messgeräte praktisch auf die oberen 200 m. beschränkt ist und die Belichtungszeit einen sehr einfachen "Intensitätsverstärker" liefert.

Die beiden ersten Abschnitte, die der Beschreibung der Tiefseekamera und der Mess- und Auswertemethode gewidmet sind, enthalten wertvolle Hinweise für den Fachmann. Die Ergebnisse der Messungen, die auf 6 Stationen (3 in der Nähe von Tahiti, 3 in der Nähe des Sargassomeeres) in Tiefen von 100 bis zu 500 m. mit Belichtungszeiten zwischen $^1/_{100}$ Sekunde und 2 Stunden gewonnen wurden, sind in 2 Tabellen zusammen mit den photoelektrischen Anschlussmessungen zwischen 0 und 200 m. und in einem Diagramm wiedergegeben; sie werden eingehend diskutiert. Es zeigt sich, dass an den Messstellen in den Tiefen zwischen 200 und 500 m. keine "optischen Überraschungen" auftreten. In den Südsee-Stationen ändert sich der Extinktionskoeffizient im Gebiet maximaler Durchlässigkeit (470 mμ) praktisch bis 400 m. Tiefe nicht, während er im Sargassomeer in Übereinstimmung mit den photoelektrischen Messungen in der Tiefe grösser ist als in der Oberschicht (s. Rep. Nr. 1). Die beiden anderen Atlantik-Stationen zeigen in der Oberschicht eine grössere Trübung, dagegen unterhalb von 100 m. Tiefe eine bemerkenswerte optische Gleichheit mit dem Sargassomeer.

Vergleichsmessungen zwischen Seitenlicht und Oberlicht geben für das Verhältnis der Horizontal- zur Vertikalintensität des Tageslichts in 400 m. Tiefe einen mittleren Wert von 60 % in annähernder Übereinstimmung mit den photoelektrischen Messungen in 175 m. Tiefe. Damit ist erneut bestätigt,

dass sich die mittlere Richtungsverteilung im Tageslichtstrom in grösseren Tiefen nur wenig ändert.

Wir können diesen Bericht als eine wertvolle Ergänzung des ersten Berichtes betrachten. Beide zusammen behandeln den Tageslichtstrom im Meere bis zu 500 m. Tiefe und nur wenig tiefer beginnt, wie auch die Verfasser erwähnen, nach den Beobachtungen von B e e b e für das menschliche Auge die vollständige Finsternis.

Joachim Joseph.

N. G. Jerlov. "Particle Distribution in the Ocean." Rep. Swedish Deep-Sea Exped. 1947—8, **3**, Phys. & Chem. No. 3, pp. 73—97, 25 figs. Göteborg, 1953.

Although the main work of the "Albatross" Expedition was concerned with the exploration of the ocean depths and of the sea floor, time was found for a number of most important measurements of the penetration of daylight into the upper layers, and of the transparency of the water at various depths. Much of this work is recorded by J e r l o v in an earlier paper (1). It has added greatly to our knowledge of the subject, and *inter alia* confirms how greatly the transparency of ocean waters exceeds that of the coastal waters in which the majority of earlier measurements have been made.

The paper under review records one particular branch of the work — the comparison of the Tyndall scattering by the particles in suspension in different samples of water. A parallel beam from a carbon arc is passed through a small (60 ml.) flask containing the sample and immersed in a larger water-vessel. A Pulfrich photometer is mounted so as to receive some of the light scattered in a forward direction through an angle of 45°, and compare the brightness of the beam thus observed in the flask with that of an etched or milk glass illuminated by a small fraction of the same beam. In this way the scattering by different samples was compared. Scattering of different colours was compared by the use of appropriate filters. Great precautions were taken to avoid contamination of the samples. Thus it was found that exposure for three minutes to the air of the cabin in which the apparatus was set up caused an appreciable rise in the scattering.

It is interesting to note that, although the scattering for blue light was considerably greater than that for red, much of this excess is attributed to the selective scattering of the water itself, leaving only a difference of some 5 % to 10 %. This, as J e r l o v points out, suggests that the size of the scattering particles generally exceeds 1 μ, a conclusion agreeing with measurements on the reduction of scattering in coastal water by filtration through collodion filters (A t k i n s and P o o l e, 2).

J e r l o v considers that in ocean waters the greater part of the scattering is due to plankton. If so it would seem probable that it is mainly due to associated mineral matter, as the refractive index of animal or vegetable tissues must be so near that of water that deviations by refraction in such particles, would seem to be chiefly limited to very small angles.

The method, which was originally due to K a l l e (3), is evidently excellent for comparing the scattering in different samples, and the paper records the striking variations found at numerous stations all round the world, and at depths down to 6000 m. Where the stations were sufficiently close it was possible to draw vertical sections showing the isopleths, dividing regions of different scattering power. This enables one to trace the flow of deep currents, and to study the interchange of water in regions such as the Straits of Gibraltar.

The results are given in terms of the scattering coefficient, which is the

difference between the extinction coefficient for a parallel beam and the absorption coefficient for the same water. He finds that, at seven different stations the ratio of the scattering coefficient to the Tyndall reading is nearly constant, so that by taking a mean value he can reduce all his Tyndall readings to scattering coefficients.

The extinction coefficients of the samples used for comparison were obtained with the Pettersson Transparency Meter, which measures the total loss in an approximately parallel beam caused by the combined effects of absorption and of scattering through more than a certain minimum angle. This minimum angle depends on such quantities as the diameters of the beam and of the receiving photo-cell, and the distance from the point of scattering to the receiving surface. It thus varies along the path of the beam (2 m.), having a very small value near the source, and rising rapidly in the immediate neighbourhood of the cell. Since it seems probable from the measurements at Plymouth (2) that much scattering takes place through small angles, we may expect that the extinction coefficient found will depend to some extent on the geometry of the apparatus used.

As Jerlov points out, this extinction coefficient differs from the vertical extinction coefficient as found by measurements of submarine daylight. In spite of the fact that the average path-length in the water exceeds the vertical depth the vertical coefficient is generally, if not always, the smaller, since scattering through small angles removes light entirely from a parallel beam, but has only a small effect on the penetration of daylight into the sea.

I have failed to understand how Jerlov gets the absorption coefficients which were subtracted from the extinction coefficients in order to get the scattering coefficients of the various samples used in calibrating his Tyndall apparatus. As, however, the Tyndall readings themselves are, as he remarks, measures of the scattering power of the water, the point is not of very great importance, except in so far as it bears on the comparison of his results with those of other workers.

This is a highly important paper recording a great amount of careful work, which has added much to our knowledge of the particle-content of ocean waters.

H. H. Poole.

(1) Reports of the Swedish Deep-Sea Expedition **3**, No. 1, 1951.
(2) Proc. Roy. Soc. B., **140**, p. 321, 1952.
(3) Ann. der Hydr. und Mar. Met., Beiheft zum Januarheft, p. 23, 1939.

B. H. Ketchum and **D. J. Keen.** "The exchanges of fresh and salt waters in the Bay of Fundy and in Passamaquoddy Bay". Journ. Fish. Res. Bd. Canada, **10**, 3, pp. 97—124, 11 figs. Ottawa, 1953.

The Bay of Fundy, with its great tides and consequent mixing of coastal and oceanic water, continues to challenge physical oceanographers.

In a short but important paper, Ketchum and Keen have brought together all the hydrographical observations made in the bay. Most of these observations were made by E. E. Watson, and discussed at length by him in 1936 ("Mixing and Residual Currents in Tidal Waters, as illustrated in the Bay of Fundy". Journ. Biol. Bd. Canada, **2**, 2, pp. 141—208). Watson lists six methods available for the study of residual currents, and points out why each method is unsatisfactory for this exceptional region. In the paper under review Ketchum and Keen apply the technique which has already given encouraging results in Raritan Bay (New Jersey), Alberni Inlet (Br.

Columbia), and Great Pond (Massachusetts), each of which is smaller and characterized by more normal conditions than the Bay of Fundy.

The bay has been divided into the segments required by Ketchum's empirical idea, and the flushing times evaluated for each, giving a value of 76 days for the whole bay. By his extension of the tidal prism concept, the exchange of river water and sea water is investigated; the accumulation of river water present in each section is calculated, and compared with the observed distribution. The non-tidal drift is also discussed.

The waters of Passamaquoddy Bay are similarly treated. The distribution of river water and salt water is again deduced, and there is good agreement with the few observations which have been made in this area.

It is obvious that Ketchum has provided a useful technique for dealing with estuarine regions. There are pitfalls, such as incomplete horizontal and vertical mixing, but these have been recognized, and their relative importance discussed by Ketchum in an earlier paper. His fundamental idea, namely, that the mixing can be characterized by a certain length — the average tidal excursion — has been investigated from a theoretical viewpoint by Arons and Stommel, 1951 ("A Mixing-Length Theory of Tidal Flushing". Trans. Amer. Geophys. Union, **32**, 3, pp. 419—21). They enunciated and solved a simplified type problem and made a comparison with observed salinity distributions in two different regions. It was encouraging to find good agreement, and it will be interesting to see the theory extended to new regions.

David Vaux.

D. I. Williamson. "Distribution of Plankton in the Irish Sea in 1949 and 1950." Proc. and Trans. Liverpool Biol. Soc., **58**, Sessions 1950—1952, pp. 1—46, 15 figs. Liverpool, 1952.

This paper on the plankton of the whole Irish Sea is pleasing evidence of the widening field of activities at Port Erin, and as the significance of the data is considered in relation to the hydrography, it undoubtedly helps to fill a gap of long standing.

As an introduction to the results of the plankton investigations, a review of the published hydrographical data of the Irish Sea is given. Plankton samples (with a few exceptions) were taken with a Hardy Plankton Indicator as, in spite of the limitations of this method, a considerably greater number of samples could be taken with this instrument than by net. The effects of diurnal migration were overcome by the simple expedient of taking all samples in daylight — one wonders if better samples would have been obtained, though less conveniently, at night — and the depth factor has not been taken into consideration.

Phytoplankton densities were graded according to colour and it is noticed that there is a tendency for the denser concentrations to occur in areas of "relatively stagnant" water. A section is devoted to the occurrence of *Sagitta elegans* and *S. setosa*, and the changing cycle of their distribution is explained by hydrographic changes. Only these two species of *Sagitta* were found, and also only two species of euphausids. The author uses the names *Calanus finmarchicus* and *C. helgolandicus* separately (following Rees) and, as would be expected, he finds both types occur with no sharp boundary between them. Like the *Sagitta*, their general distribution can be explained hydrographically, *C. finmarchicus* having its origin from the north. *Isias claviceps*, on the other hand, originates from St. George's Channel in the south. The distribution of other Copepoda, Cladocera, *Tomopteris*, and *Oikopleura* are also dealt with.

Discussion sections follow, which are both valuable and interesting. The author considers the proportion of *S. elegans* to *S. setosa* in the Irish Sea to be greater than would be expected from the literature dealing with adjoining areas, and he suggests some factor other than the mixing of coastal and oceanic water (i.e., mixing of salinities according to the argument) must be playing a major part in determining the *Sagitta* populations. Such a factor has been frequently postulated. Nevertheless W i l l i a m s o n' s data may be useful also in the evaluation of *S. elegans* as an indicator in areas outside the Irish Sea. Regeneration of phosphate is suggested as a tentative possibility for this factor. The four main Irish Sea water masses, and the biological indicators found in them, are separately discussed. The reviewer was particularly pleased to see that the author used what information he had to stress, against previous opinions, that the south-going current on the Irish side of the North Channel had an outside origin, probably off the north Irish coast, and was not merely a backwash of the main north current on the east side. It is here that the limitations of the Hardy Indicator as a method of sampling became most apparent, as with catches from increased volumes of water and from different depths the author could have obtained a much greater weight of evidence. In addition to *Calanus finmarchicus* and *Meganyctiphanes norvegica* found by W i l l i a m s o n, "outside" species such as *Sagitta serratodentata, Agalma elegans, Pleuromamma robusta,* and *Thysanoessa longicaudata* have been taken from this stream by the Scottish "Explorer" on her infrequent visits to that area. A comparison with earlier years is made, which appears to indicate that there has been but little change in the general plankton population of the Irish Sea, and contrasts strongly with the changes recently recorded from the western end of the English Channel.

J. H. F.

T. Braarud and **B. Hope.** "The annual phytoplankton cycle of a land-locked fjord near Bergen (Nordåsvatn)". Fiskeridirek. Skr., Ser. Hav-unders., **9**, No. 16, pp. 1—26, 4 figs. Bergen, 1952.

The Nordåsvatn is a small body of water near Bergen with a maximum depth of 84 m. It opens by a narrow passage with a shallow sill into the more open waters of the Grimstad Fjord and receives fresh water as well as a rich supply of sewage at the other end. During the winter it is covered with a layer of ice and snow. Altogether it provides an example of a specialized hydrographical and biological environment. This paper describes the phytoplankton cycle in 1941—1942 and relates it to the physical and chemical changes. The hydrography and zooplankton have already been dealt with.

The ice cover during winter and early spring prevented the penetration of light and the spring diatom increase came only when the ice had melted, much later than in the neighbouring Norwegian coastal waters. Although the water was found to be rich in diatoms before this time, they had been carried in from outside over the sill, and the oxygen content indicated that they were not photosynthetizing. The indigenous spring increase took place in the second half of April and the species predominant then were not those characteristic of the coastal water.

During the rest of the summer there was a large number of short-lived increases caused by a remarkably heterogeneous collection of species, including diatoms, dinoflagellates, coccolithophores, and desmids. Some of these were brought in from outside, some were brackish or freshwater forms, and some,

dependent on a rich supply of nutrients, owed their abundance to the presence of sewage.

The authors think that the presence of H_2S in the deeper layers limits the zooplankton to the surface photosynthetic zone so that grazing is continuous and its effects are more marked than is usual in such waters.

This interesting study of an unusual and complicated environment throws light on some of the factors which may operate also under more normal conditions.

S. M. M.

H. W. Harvey. "Synthesis of organic nitrogen and chlorophyll by *Nitzschia closterium.*" Journ. Mar. Biol. Assoc. U. K., N. S., **31**, 3, pp. 477—87, 4 figs. Cambridge, 1953.

Im Jahre 1939 fand B. H. Ketchum an *Chlorella*-Kulturen, die nur geringe Mengen Nitrate oder Ammoniumverbindungen enthielten, dass die Photosynthese und Zellteilung auch dann noch weiterläuft, wenn aller verfügbare Stickstoff aus der Lösung aufgebraucht ist. Jedoch sind diese offenbar Stickstoffmangel leidenden Zellen in der Lage, weiterhin zugesetztes Nitrat in der Dunkelheit zu organischen Stickstoffverbindungen zu synthetisieren.

Auf diesem Befund aufbauend setzt der Verfasser mehrere Versuchsreihen an Kulturen der marinen Diatomee *Nitzschia closterium*, die unter künstlichen Stickstoffmangel gesetzt sind, an, um die hier vorliegenden eigenartigen Beziehungen im Stickstoff-Stoffwechsel des Phytoplanktons weiter zu klären.

In Übereinstimmung mit den obigen Versuchsergebnissen findet Harvey, dass auch in *Nitzschia*-Kulturen unter den entsprechenden Verhältnissen zugesetzte anorganische Stickstoffverbindungen im Dunkeln in wenigen Stunden zu organischen Stickstoffverbindungen aufgebaut werden. Über die Versuche Ketchums hinaus ergibt sich, dass der Vorgang der Stickstoff-Synthese besonders schnell bei Zugabe von Ammonium, weniger schnell bei Zugabe von Nitrat und nur in ganz geringem Masse bei Zugabe von Nitrit vor sich geht, obwohl die Pflanzenzellen im Lichte alle drei Verbindungen etwa gleich stark ausnutzen können. Dieser Befund legt den Schluss nahe, dass die bisherige Annahme, dass das Nitrit das erste intermediäre Zwischenprodukt bei der pflanzlichen Assimilation des Nitrats ist, nicht zu Recht besteht.

Bei den obigen Versuchsreihen zeigte es sich, dass die unter Stickstoffmangel sich vermehrenden Zellen beträchtliche Abblassung ihres Farbpigments zu erkennen gaben, während im Gegensatz hierzu die Kulturen, die nach Zugabe von Stickstoff im Dunkeln standen, eine erhebliche Farbvertiefung zeigten. Versuche, diese Befunde quantitativ zu unterbauen, zeigten, dass bei der Chlorophyllentwicklung sowohl die Lichtverhältnisse wie die Aufnahme der Nährstoffe eine Rolle spielen, dass sie aber nicht die einzigen Faktoren sind, welche den Gehalt der Zellen an Chlorophyll und das Verhältnis zwischen den gelben Farbpigmenten und dem Chlorophyll bestimmen.

K. K.

M. Sears. "Notes on Siphonophores 2. A Revision of the Abylinae". Bull. Mus. Comp. Zool., Harvard College, **109**, 1, pp. 1—119, 29 figs. Cambridge, Mass., 1953.

Basée principalement sur l'étude des siphonophores récoltés par le "Dana" (1928—1930), la description détaillée des Abylinae est mise en valeur par les nombreux dessins qui en soulignent les caractères anatomiques.

L'auteur crée deux genres (*Pseudabyla, Abylopsoides*) à cause du nombre moins élevé des facettes de leurs cloches supérieures; ces genres feront certainement l'objet de considérations critiques attentives.

Bien qu'incomplète, une liste des lieux où le "Dana" a recueilli les collections, permet de se faire une idée de la distribution géographique des espèces actuellement connues.

En résumé, la révision de l'éminente spécialiste M. Sears constitue un document précieux pour l'étude de la sous-famille des Abylinae.

E. Leloup.

D. T. Gauld. "Diurnal variations in the grazing of copepods". Journ. Mar. Biol. Assoc. U. K., N. S., **31**, 3, pp. 461—74, 3 figs. Cambridge, 1953.

This paper forms a natural continuation of an earlier paper by Dr. Gauld (1951) on the grazing rate of copepods. The purpose of the investigation was to discover a possible rhythm in the feeding of *Calanus finmarchicus*, both in nature and under laboratory conditions. Material was obtained from horizontal net hauls at different levels at 4-hour intervals over 24 hours. Dr. Gauld found it necessary to examine the animals before preservation, because the addition of formalin caused defaecation by many of the animals.

It was found that 80—100 % of the *Calanus* caught at the surface were full of food at all hours of the day. The number of animals containing food in deeper water was distinctly less. This may be related to the greater abundance of food close to the surface. In an experiment in which hauls were taken at 6 depths and water samples for phytoplankton at roughly corresponding depths, the phytoplankton was observed to be concentrated in a narrow stratum about 10 m. deep, in which 90 % of the *Calanus* were full. Below this stratum the percentage fell steadily from 40 % at 10 m. to 5 % at the bottom. It might be suggested, however, that the mechanical disturbance experienced in connexion with the rapid change in pressure, might cause defaecation in a certain percentage of the *Calanus* taken in the deepest hauls.

In the laboratory experiments, the copepods were first kept in sterile sea water for some time to ensure that they were empty; they were then kept in a suspension of a food organism, usually a species of *Chlamydomonas*, and examined at intervals. The results showed that in thick suspensions *Calanus* can fill their gut in 10—15 minutes or less. Even in suspensions comparable in density with those found in nature the gut was filled in less than 30 minutes. The bulk of the food is digested, and undigestable residue passed out in 1 to 2 hours. Feeding was not continuous, and there were apparently long gaps between meals, but no consistent rhythm in feeding and resting could be seen. Some stage V copepodites spent a long time in a dense suspension of food without feeding. It would have been of interest to know the temperature in the different layers of the sea at the time of the investigation, and also during the experiments, as the filtering rate is probably related to temperature in the same way as is respiration (Gauld, 1951).

Dr. Gauld concludes that in nature alternate feeding and non-feeding periods take place only when there is a marked diurnal migration, into surface water rich in food at night, and down into deeper, more barren water by day.

Wimpenny's previous suggestion that the feeding of *Calanus* takes place mostly at night may therefore be correct to some extent, but the reason for this is that by day *Calanus* are usually absent from the surface water in which their food is mainly present.

On some occasions the *Calanus* were evenly distributed between bottom

and surface throughout the 24 hours. A proportion of the animals taken in the deepest hauls contained food. In the water in which they were caught these copepods were apparently unable to maintain themselves. It may therefore be possible that although the population as a whole did not appear to undertake vertical migrations, it was in a continuous state of flux, some *Calanus* migrating upwards to feed and others downward out of the rich water at all hours of the day. The stimuli inducing these movements may be hunger and repletion.

Dr. Gauld's paper is very well written and adds considerably to our knowledge on the feeding of copepods.

Kr. Fr. Wiborg.

J. E. Shelbourne. "The feeding habits of plaice post-larvae in the Southern Bight". Journ. Mar. Biol. Assoc. U. K., N. S., **32**, 1, pp. 149—159, 2 figs., 1 pl. Cambridge, 1953.

Earlier investigations had shown that post-larval plaice fed on larvae of annelids and molluscs, small copepods, and other pelagic crustaceans.

The post-larvae now investigated were caught in the southern North Sea between late January and the end of March in the years 1946—47 and 1950—51. In all years except 1947 the tunicate *Oikopleura dioica* formed the main content of the stomachs. Simultaneous investigations of the plankton showed that *Oikopleura* spp. constituted only a small fraction of the plankton, indicating that the plaice post-larvae may be selective in feeding. In 1947 *Oikopleura* were almost totally absent from the plankton samples. Green food remains, identified as the large diatoms *Coscinodiscus* and *Biddulphia*, invariably formed part of the stomach contents. Copepod larvae were also found.

Mr. Shelbourne discusses the possible causes of food selection and is of the opinion that the vulnerability of the prey, which depends on their size, structure, and behaviour, may be of importance, as well as the hunting ability of the predator; he suggests that *Oikopleura* are very suitable as food for the plaice post-larvae, being soft-bodied and slow-moving, and at the same time very conspicuous because of their vibratile movements. The mechanism of selection is, however, far from being clear, as the plaice post-lavae sometimes contain a number of different food organisms and may be successfully reared in the laboratory on food quite different from that present in the sea.

A large percentage of the post-larvae investigated had empty stomachs. This condition has been observed by earlier investigators and ascribed partly to infrequent feeding coupled with rapid digestion, and partly to regurgitation in the net or on addition of preservative. Mr. Shelbourne studied the latter possibility. On a 24-hour station, when 2 vertical Hensen-net hauls were taken every 2 hours, the post-larvae from one haul were investigated in the fresh state. The other sample was immediately preserved and investigated later. No significant difference was found in the frequency of empty stomachs in the two samples during 24 hours of work. Feeding was found to have a marked diurnal rhythm, being most intense in the first hours of daylight and then for a period before darkness. No feeding was observed during the night. In laboratory experiments with nauplii of *Artemia salina* as food, post-larvae were never found feeding in darkness, and the impression that plaice post-larvae are visual feeders was further confirmed.

It would have been an advantage if the figures given in Table II and III had been reduced to average values and arranged so as to be directly comparable with those in Table I. The information given on the feeding of post-larval fish is very useful. Further laboratory experiments on selective feeding would be of great interest.

Kr. Fr. Wiborg.

N. A. Holme. "The biomass of the bottom fauna in the English Channel off Plymouth". Journ. Mar. Biol. Assoc. U. K., N. S., **32**, 1, pp. 1—49, 7 figs. Cambridge, 1953.

This paper is one of a series of most valuable publications on the biology of bottom invertebrates and the technique of quantitative sampling which the author has published during recent years.

The scope of the present investigation was to find out whether the bottom fauna of the Plymouth area had changed in recent years. Changes were to be expected because the fertility of the sea water off Plymouth has decreased since the early nineteen-thirties, with the result, for instance, that some species of planktonic animals have been substituted by certain others (R u s s e l l). A slight decline in the biomass of the bottom fauna was observed, although the precise situation is obscured by the fact that previous authors (A l l e n, F o r d, M a r e, and others) used other methods of sampling and sieving the material. It is intended to continue the investigations, in order to follow such changes as might appear in future.

An inspiring method for estimating the total number of species actually occurring in a certain area is taken from plant ecology (W i l l i a m s). With an increased area of sampling an increased number of species is obtained. When plotting the number of species against the logarithm of the area sampled a straight-line relationship is approached. The approximate number of species to be expected when the area is doubled, trebled, and so on, can be read from the curve.

Two new bottom samplers are introduced — a double-scoop modification of the Holme single-scoop sampler, and a new "suction-corer". The double-scoop sampler is much like the original single-scoop type, but in each haul two samples covering about 0·05 sq. m. each are obtained, as against only one in the single-scoop sampler. The new type seems to be particularly valuable for estimating the patchiness of the fauna. For many species almost as much variation was found between the pairs of samples from one haul as between samples in successive hauls within a distance of half a mile.

The suction-corer has some resemblance to the Knudsen bottom sampler for hard bottoms. It consists of a coring-tube 36 cm. long, the top of which is in communication with an air chamber. When the bottom is reached a tap is opened to give a negative pressure in the coring-tube. The area covered is approximately 0·025 sq. m. The advantage of this small instrument over the Knudsen sampler is not quite clear.

Comparative hauls were carried out on a bottom of fine, muddy sand with the suction-corer (14 hauls), the single-scoop sampler, and an 0·1 sq. m. Petersen grab (5 hauls each). The mean penetration of these instruments into the bottom was 16·6, 6, and 3 cm., respectively. The number of animals obtained per sq. m. was 884, 976, and 230, respectively. From this and previous comparative hauls (H o l m e, 1949) it is obvious that the scoop-sampler is superior to the 0·1 sq. m. Petersen grab used. Unfortunately particulars of the weight were given for the single-scoop sampler only. It

would be interesting to have the scoop-sampler compared with the 0·2 sq. m. van Veen grab which (at least in the Danish modification) is a very handy instrument, and procures fairly good samples in shallow water.

The loss of animals through the sieve is discussed. Most investigators used a sieve of 1·2—1·5 mm. mesh, but here a 2·2 mm. sieve was used. The author concludes that most often about 50 % (by number) of the animals retained in a 1·2 mm. sieve are lost through one of 2·2 mm. mesh. However, 10 % only of the dry weight of animals is lost.

It is discouraging always to find difficulties occurring when quantitative studies of the bottom fauna are to be compared. It would seem as though no two authors had ever used the same sampling methods. Obviously, the perfect bottom sampler is still lacking.

Erik Ursin.

(Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.) "Marine Fouling and its Prevention." Prepared for Bureau of Ships, Navy Dept., pp. X + 388, frontispiece + 227 figs. U. S. Naval Inst., Annapolis, Maryland, 1952.

It had been known for a long time that a ship's performance was very much affected by the amount of fouling present on the hull, but during World War II antifouling researches were appreciably accelerated in a number of countries; in particular both Great Britain and the United States of America had teams working on this subject for a number of years. The publication of "Marine Fouling and its Prevention" by the U. S. Naval Institute has brought together a valuable collection of data on the subject. Whilst primarily an account of the work of the Woods Hole team together with that of their naval colleagues, it does full justice to that of the British workers. All the sections are of interest to marine biologists even though they are not directly concerned with the chapters dealing specifically with the effect of fouling on performance — a problem of applied physics — or with the chapters on the prevention of fouling and the physical chemistry of the release of toxic materials from paints. They are, however, of great importance, and in no other place has the relevant literature been collected together. Further, some of these chapters contain information not otherwise available, since much of the work has never been previously published.

The marine biologist will be more interested in the eight chapters of Part II on the biology of fouling, since this is essentially a problem of marine ecology. In this section are collected much valuable data on the temporal sequence and biotic succession of sedentary marine organisms in various climatic regions, and the text is supplemented by nineteen charts. The latter cover both temperate and tropical regions. The effect of variation in the environment on the development of such fouling communities is considered. For those not well acquainted with the problem there is a comprehensive list of the principal fouling organisms, together with a list of all the recorded species. The chapter containing this list, with its some one hundred and fifty references, should be found useful to those working on sedentary organisms.

To summarize — this book will be found of interest to a wide number of workers in marine biology and should find a place in the library of many laboratories.

H. Barnes.

E. Bertelsen. "The Ceratioid Fishes: Ontogeny, Taxonomy, Distribution and Biology". Dana-Report No. 39, pp. 1—276, 141 figs., 1 pl. Copenhagen, 1951.

During the "Dana" Expeditions of 1920—1922 and 1928—1930 nearly four hundred adolescent and adult ceratioid angler fishes were taken. These individuals were dealt with by Regan[1]) and Regan and Trewavas[2]). By working through the "Dana" collections Dr. Bertelsen found additional material in the shape of some 2,400 larval ceratioids; and it is particularly the study of these that forms the basis of the above report. It is a masterly account, providing new insight to the systematics, distribution, and biology of this fascinating but difficult group of bathypelagic fishes.

The ceratioids are difficult to study because of their extreme sexual dimorphism. The males are much smaller than the females and have slimmer bodies without a lure (illicium) and bait (esca) on the snout, while the jaws and alimentary canal are less well developed. Parasitic males have been found attached to female *Caulophryne jordani, Neoceratias spinifer, Ceratias holboelli, Cryptopsaras couesi, Photocorynus spiniceps, Borophryne apogon, Edriolychnus schmidti,* and *Linophryne argyresca.* But among the "Dana" catches were 166 free-living males.

Bertelsen found that a difference between the sexes could be detected even in quite early larval stages, the females showing a distinct "Anlage" of the illicium. By means of fin-ray counts and a study of the pigment pattern the larvae were divided into a number of types and then assigned to a definite family from the osteological characters of the largest individuals. A particularly valuable discovery was that the subdermal pigmentation of the larvae usually persisted after the skin had darkened during metamorphosis. Bertelsen was thus able to fit all but one larval type to known genera of ceratioids and usually to definite species. Concerning the free-living males, 27 types were found, all of which could be placed in genera as defined by the females and 14 to species.

By means of these studies of the ontogeny and an increased knowledge of the free-living males, Bertelsen has radically revised the systematics of the ceratioids, this forming the first part of the report. The family Laevoceratiidae has been discarded, the Photocorynidae included in the Linophrynidae, and a new family, the Centrophrynidae, proposed. Bertelsen regards the Caulophrynidae as the most primitive family, particularly as he found that the larvae have pelvic fins, the lack of which had previously been thought to distinguish the ceratioids from other angler fishes. The number of genera and species has been greatly reduced, the former from 46 to 34 and the latter from 178 to 119.

The second part of the report deals with the distribution, ecology, and biology. A careful analysis of net catches shows that the adults have a centre of abundance at about a depth of 2,000 metres; that the larvae occur mainly in the upper 100 metres; and that the onset of metamorphosis leads to a rapid sinking to a depth of 1,000 metres or more. The depth at which spawning takes place is unknown, but Bertelsen shows clearly that in the North Atlantic most of the ceratioids are summer spawners. The larvae only occur in the warmer parts of the ocean, and it is concluded that the adults have a fertile

[1]) Regan, C. T. 1926. "The pediculate fishes of the suborder Ceratioidea". The Danish "Dana"-Expeds. 1920—22, Oceanogr. Rep., No. 2.

[2]) Regan, C. T., and Trewavas, E. 1932. "Deep-sea angler-fishes (Ceratioidea)". Dana-Rep. No. 2.

distribution between the north and south subtropical convergences. Bertelsen suggests that the vertical distribution of the larvae is mainly determined by light; for metamorphosis stages, adolescents and adults, the upper limit (ca. 1,000 m.) seems to be related to temperature and the lower (2,000—3,000 m.) to the quantity of food.

The section on general biology covers swimming, luminescence, food and feeding, and reproduction. With the exception of *Caulophryne* and *Neoceratias*, all female ceratioids have an esca light organ, which in certain species contains luminous bacteria. Bertelsen accepts the view of earlier workers that as oxygen is necessary for the luminescence of bacteria the switching on and off of the light is done by regulating the blood supply to the esca. On the "Dana" he was able to show that the dorsal caruncles of *Cryptopsaras* females are luminescent structures, producing a yellowish secretion which on contact with water breaks up into luminous points of light.

Larval ceratioids were found to feed on copepods and chaetognaths. The females take other bathypelagic fishes but crustacean remains are almost as common among the stomach contents. Of the free-living males, only those of *Himantolophus groenlandicus* and *Melanocetus* were found with food in the stomach. Concerning the parasitic males, there seems no doubt that these are dependent on the females for nourishment; but the available evidence suggests that the males of the Himantolophidae, Oneirodidae, Melanocetidae, and Gigantactidae never become parasitic. However, these males have a well developed denticle apparatus at the front of the jaws, by means of which they probably nip on to the females for the spawning period.

Many males have highly developed eyes or olfactory organs, or both, which no doubt play an important part in the search for females. Bertelsen agrees with Regan that a most significant feature of this extreme sexual dimorphism is that when ready to "pair" the males are younger and a good deal more numerous than the slower maturing females: the chances of meeting are thus increased.

The foregoing is but an incomplete outline of a closely reasoned account — a study which has not only increased our understanding but given sharper perspective to many problems. Apart from taxonomic uncertainties, such as the status of the species of *Melanocetus* and *Oneirodes* (the definition of which must await more material), the sections on locomotion, the breeding cycle, the structure of the eye, the escal light, and the lateral line organs are of particular interest. These will be taken in order.

The ceratioid fishes have capacious gill chambers and the exhalent openings are small and placed well back along the body. Bertelsen considers that the outflowing respiratory jets have a considerable propulsive effect: the morphology of the branchial mechanism would be well worth further study. Regarding spawning, the point is made that although the deep-sea angler fishes live at depths where there can be little or no seasonal change in the physical factors, there is a breeding cycle. Perhaps the seasonal rhythm in phytoplankton production, which is presumably reflected into deep water by way of food chains, may be of importance. One is tempted to think of the exciting (but as yet inconclusive) work on carotenoids and fish reproduction.

Turning to the eyes, Bertelsen stresses that many male ceratioids have these well developed, with a relatively large lens, an oval pupil, and a large aphakic space. In many shallow-water fishes the latter is often associated with a temporal fovea; and as Brauer's (1908) diagrams suggest, this is true in the young of a bathypelagic fish, *Bathytroctes rostratus*. Further work on the ceratioids and on other bathypelagic fishes with an aphakic space in

front of the lens should yield interesting comparative data on modes of vision in deep water.

More work needs to be done on the escal light organ. Does the light come from an inner culture of luminous bacteria in all ceratioids? If the blood supply does act as a bacterial light switch, this is another way in which bioluminescence can be controlled. Finally there is the interesting observation by Bertelsen that in *Caulophryne* and *Neoceratias,* which have no escal light organ, the lateral line papillae are particularly well developed. Comparative studies on the fine structure of the lateral line organs in different types of ceratioids should be revealing.

It only remains to be said that these are but a few of the lines for future work suggested by this comprehensive report. There are many new facts and Dr. Bertelsen has seen new ways of relating them. That he was able to do so is also a measure of the wealth of deep-sea fishes in the "Dana" collections.

N. B. Marshall.

B. B. Parrish and **R. Jones.** "Haddock Bionomics 1. The State of the Haddock Stocks in the North Sea 1946—50 and at Faroe 1914—50". Scottish Home Department, Marine Research, 1952, No. 4, pp. 1—27, 7 figs. Edinburgh, 1953.

The Faroe trawl fishery takes cod principally, haddock being second in importance. Nearly all is landed in British ports. From records of the fishing done and catch made by Aberdeen trawlers the authors plot a graph of catch per 100 hours of trawling (C/E), for the whole period 1914 to 1950. Figures for all British trawlers, as far as available, have much the same trend as those for Aberdeen. A marked decrease in fishing effort during the later years of World War I was followed by an equally abrupt increase in C/E, while the lesser but more protracted decrease of World War II produced a less marked rise in C/E. Between the wars C/E was low, but varied by a factor of 2 or 3, with highs in 1926—27 and 1937—38.

In analysing these data the authors make use of and extend Beverton and Holt's improvement on Baranov's theory of change in age structure of a stock under exploitation, when recruitment is constant. The improvement stems mainly from a more realistic curve of the length-age relationship, replacing Baranov's linear function, and is obtained at the expense of some fairly heavy algebra. (One wonders if it would not have been simpler to estimate instantaneous rate of growth at successive ages directly from a graph of log weight against age, combine it with the mortality rate to get net change and average weight of stock in each year of life, and from the latter calculate the catch from each age-group separately. This would have the added advantage of greater flexibility in dealing with the lesser vulnerability of broods while they are in process of recruitment — particularly when, as here, there has been variation in the size at which recruitment begins.)

To compare observed and expected changes in C/E for the World War I period, an instantaneous mortality rate of 1·26 is computed "from 'Explorer' records" (presumably age-frequencies) for the period 1923—39, and a natural mortality of 0·14 is assumed, giving an instantaneous rate of fishing (F) of 1·12. From this, F for 1914—16 is computed as 0·61, using the relative number of hours of fishing done (with a correction for change in kind of gear); for 1918—19, F becomes 0·12 on the same basis, except that natural mortality is given the larger value of 0·18. These figures, and also some based on two

other pairs of natural mortality rates, are applied in the Beverton-Holt formulae; the resulting ratios of 1918—19 to 1914—16 stock are from 2·06 to 2·69. These are compared with the observed 1918—19/1914—16 C/E of about 3, and the agreement is considered satisfactory; also, a comparison for each individual market category gives concordant results.

For the period 1934—1950 a similar computation is made, but the value of F is estimated for each calendar year and each individual year-class of fish is considered separately, the relative stock present each year being the sum of the contributions of all year-classes present in significant numbers. In this case the estimated C/E for the war years does not agree well with the observed — the latter is bimodal instead of unimodal, and the observed maximum is less than half the expected. Explanation of the discrepancy is largely left in abeyance; varying recruitment would seem to offer the most obvious possibility, particularly in the light of the between-wars' ups and downs.

In a rather brief treatment of the North Sea haddock fishery, the authors show that in post-war years C/E fell to its pre-1939 level, though British trawling effort was only about half as great. However, data on total effort are not available, and it is known that some other types of haddock fishing have increased. At any rate the age-frequency estimate of instantaneous mortality rate during the post-war period (1·02) was practically the same as an estimate for the time immediately preceding the war.

Finally, for both the Faroe area and the North Sea a computation is made of yield at different levels of total mortality, at constant natural mortality rates of 0·11 and 0·22 in each case. Like similar models for other species in this general region, all four graphs indicate that "equilibrium" catch would be increased by reducing present fishing effort. However, they suffer from many of the same limitations as earlier models, that it is for only a limited range of stock sizes and total mortality rates that growth, natural mortality, and recruitment are known, and these may conceivably change sufficiently to make the computation quite misleading, particularly at the smaller mortality rates. For example, could the apparent deficiency of Faroe haddock stock during World War II have resulted from reduced recruitment consequent upon an increased density of large fish (cod as well as haddock) on the grounds? An analogous inverse relation between stock and recruitment has been demonstrated by H e r r i n g - t o n for a New England haddock stock during the period 1912—1930. In this connexion, too, one wonders why the authors used a constant natural mortality rate in this computation, whereas earlier, in dealing with the Faroe stock, they let natural mortality increase at the times fishing decreased.

In summary, the paper contributes a valuable review of biological data on the haddock fishery in the two regions, it contains what is apparently the first printed account of an extension of the theory of analysis of such data, and it gives perhaps an indication that less fishing would yield more haddock.

W. E. R.

A. Bückmann. "Die Untersuchungen der Biologischen Anstalt über die Ökologie der Heringsbrut in der südlichen Nordsee. II. Teil." Helgoländ. Wiss. Meeresunters., **3**, pp. 171—205. List (Sylt), 1950.

The first part of this paper, published in 1942, dealt with the distribution and the size of the herring larvae in the southern part of the North Sea and the eastern part of the English Channel in autumn and winter. The second part has now also appeared (1950) and deals with the herring larvae in the inner part of the German Bight.

The author experienced several disappointments in working up the huge material, comprising more than 47,000 larvae. It proved next to impossible to trace the larvae back to their respective spawning places. The time-consuming process of extensive vertebral counts on the larvae in order to establish their origin was not successful. Attempts to estimate the density of larvae in the area were also a failure, and no connexion between the occurrences of larvae and of young herring could be found. The author himself says laconically about this part of the investigation, "So ist das Ergebnis der Küstenuntersuchungen bescheiden und jedenfalls nicht das ursprünglich erwartete."

But even if the investigation did not yield the expected results, there are nevertheless many points of interest. This especially applies to the sections on the vertebral counts and the studies on the development of the caudal skeleton of the larvae, which provide very interesting reading indeed. This is particularly true for the part about the occurrence and significance of the complex structures of the vertebral column of the herrings. The author succeeds in demonstrating most convincingly that the formation of both dorsal-complex and amphi-complex structures are governed by the same principle — space conditions and function — although they arise as antagonistic consequences of that principle; the dorsal-complexes are due to excess of space while the amphi-complexes are caused by the lack of it.

It is also an interesting and surprising fact that (within the same year) the larger larvae have the higher vertebral number. The author explains this as due to selection; the minus-variant loses in the struggle for existence. Furthermore, it is worth noticing that the year-broods differ significantly in their mean vertebral numbers and that there is apparently a fairly distinct correlation between the sea temperature and the vertebral number.

There is ample reason to congratulate the author on this valuable paper. It is written in a very clear German that is easily readable even for foreigners. The few misprints are fairly obvious and should not lead to confusion.

Olav Aasen.

J. C. Stevenson and **J. A. Lanigan**. "Results of the West Coast of Vancouver Island Herring Investigation, 1949—50." Prov. Dept. Fish., Rep. for Year 1949, pp. 41—80, 3 figs., 16 tables. Province of British Columbia, Victoria, B. C., 1950.

This report is the fourth in an annual series covering a long-term programme initiated to study the question whether catch quotas are effective in stabilizing a herring population. Perhaps it is not very wise to review the results of this work before it has been brought to a conclusion. On the other hand, the Canadians are now well advanced in their investigation of a problem of common interest to all who study the herring, and it would perhaps be of advantage if European research workers also paid some attention to the progress of this work.

Stevenson and Lanigan propose to solve their problem by tagging and sampling, and by studies of the extent and intensity of spawning. Whereas tagging and sampling are well known methods for population studies, the charting of the extent and intensity of spawning has only been employed to a small degree in European waters for estimation of abundance. Such work is bound to encounter many practical difficulties, and to the reviewer's mind, the results ought to be regarded with reserve.

As regards the taggings and the tag recoveries, the technical problems facing Stevenson and Lanigan are strikingly similar to our own in Norway, which is only to be expected, as we employ the same method. They have recorded several interesting details which are instructive for our own research; for instance, it seems that a large tagging mortality is induced by taggers with little experience in the tagging technique. Also the authors' experience with tag-detectors is worth a closer study. The general agreement of detector returns and plant returns comes as a relief to us, since we have not hitherto been able to employ tag-detectors.

The sampling of the catches and spawning runs follows familiar lines and does not present many new points of interest, except, of course, to research workers in that particular region; the work appears to have been excellently carried out and the discussion seems sound. There are, to be sure, interesting details to be picked up from the tables; for instance, the herring, *Clupea pallasii,* appears to be relatively small sized and short lived and to attain early maturity. In this respect it resembles strikingly isolated local tribes found in some of the Norwegian fjords.

Olav Aasen.

A. R. Molander. "The Sprat Fishery and the Sprat of the west Coast of Sweden". Rep. Inst. Mar. Res. Lysekil, No. 2, pp. 1—67, 11 figs. Stockholm, 1952.

A most comprehensive review of the location and size of the sprat fisheries on the Swedish coast, Kattegat, and Skagerak is given. Each fishery is treated separately with regard to the quantity of sprats landed during the season, and the composition of the catches in terms of year-classes is described.

The type of fishing, number of boats, etc., are mentioned but good statistics of fishing effort are not available, although the author says that little change in the effort has taken place and therefore comparisons may be made between years.

The main year-class is the I-group in the skerries whereas the offshore grounds, Kattegat, and Skagerak yield mainly older fish and, in general, there is a movement of both fish and fishery westwards towards the Swedish coast and then in spring farther westward, when the fish are lost. The author points out the relationship between the inshore and offshore fisheries and the need for a good I-group to produce a good fishery in the skerries. He draws attention to the remarkable alternation of good and poor year-classes which are shown in the form of the percentage age-composition for each season. It is stated that there may be poor sampling on the offshore grounds when there is a good inshore fishery, and for this reason and the difficulty of interpreting the actual size of a year-class for comparison, the clear-cut alternation of good and poor I-year groups pointed out by the author is open to doubt. Further doubt is raised in a later hypothesis concerning the effect of climatic conditions on the success of a spawning.

After dealing very fully with the various fisheries along the Swedish coast, the author attempts to explain the causes of the fluctuations both in size of the year-classes and in the size and place of the catches.

Firstly, there is the suggestion that temperature might be important for aggregation of sprats. Various examples are given of the way in which a good fishery results from sprats aggregating in the warmest water available, often at the bottom of the skerries.

Secondly, the influence of salinity on the concentration of sprats is discussed.

It is pointed out that the inflow or outflow of water in the skerries alters the salinity ranges greatly and this might affect the movements of the sprat.

The author has previously pointed out that the amount of rainfall can be related to the catches of sprats in the skerries. In this paper he repeats this hypothesis, suggesting that rainfall, although only an indication of general weather conditions, does bear some relationship to the total catch on the inshore grounds. Unfortunately, the correlations which are given in this paper between rainfall and catch both in autumn and winter bear no tests of significance, which, had they been applied, would probably have shown that the correlations were extremely poor.

In a discussion of the effect of wind on water flow and the resultant effect on the catches, it is stated that some winds produce good inshore fisheries and some poor fisheries, and here the author quotes C a r r u t h e r s on the effect of wind on water movements.

Obviously there is some factor or number of factors which influences the migrations of the sprat to the inshore waters and produces good fisheries. It may be temperature, salinity, or wind-formed currents, but whatever the cause it must be a direct one and although the author feels that he is not certain of the answer, he introduces some extremely interesting problems.

In conclusion, the influence of weather, i.e., the number of calm days, on the success of a particular spawning is discussed.

I. D. Richardson.

K. Radway Allen. "The Horokiwi Stream. A study of a trout population". New Zealand Mar. Dept., Fish. Bull. No. 10, pp. 1—231, 22 figs. + 12 pl. Wellington, 1951.

The introduction of trout into New Zealand has had a happier outcome than some other attempts at acclimatization and the freshwater fisheries of New Zealand are now world-famous. In recent years biologists, both academic, like P e r c i v a l, and in Government Service, like H o b b s and A l l e n, have set out to study the problem of the trout population on a proper scientific basis.

The author found a stream of manageable size, about ten miles in length, so that he could make a study of the major part of it, and he also was able to obtain reliable data on the previous history of the trout fisheries of the stream and information on catches of fish from anglers during the course of his investigation. As a result he is able to give an account which, within certain stated statistical limits, is an accurate assessment of the trout population for the years 1940 and 1941. He gives the birth-rates and death-rates of the fish at various stages and relates them as far as he can to external conditions. He tells what they feed on, how much they eat, and how much of what they eat goes to form trout flesh. He has worked out the relation between the stock of fish, which for the whole stream is normally just over a ton, and which varies in different parts between 100 and 400 lb. per acre; the production, which amounts in a year to about twice the stock; and the crop, which in the lower waters is about 5 per cent. of the production and in the upper waters only about 1 per cent. These are startling figures which should be pondered by all those concerned with fishery management.

In his deductions from his data Mr. A l l e n is notably restrained but it is interesting that he remarks in his summary, "Except, perhaps, for the close season, the only management practice which has any significant effect on the crop of trout at present is the size-limit. This determines the time of cropping in a year-class; in the lower waters the eleven-inch limit gives a very satisfactory balance between the cropping point desirable for maximum efficiency

and that necessary to protect the breeding stock; in the upper waters the cropping point is much too late, and leads to very inefficient utilization". It is pertinent to remark that of no stream in England and Wales have we sufficient information to make that sort of assessment of fishery regulations.

The report is not easy reading. Mr. A l l e n takes nothing for granted himself, and he requires an equal detachment in his reader. Consequently every statement is weighed, measured, and assessed so that its exact value is precisely defined. This scientific rigour is of course admirable and we could all with advantage study the technique of this paper but it does not make for ease of reference. Everyone who has engaged in this kind of study will acknowledge that Mr. A l l e n is a prodigious worker with his brain as well as his hands and will feel that he has well deserved the highest commendation of his results.

Lest I should give the impression that this report is of interest only to the angler and fish farmer, I should make it plain that it is a most valuable ecological study of a predatory animal. It deserves the attention of every biologist who is concerned with the study of organisms in their environment and should be placed on the bookshelf alongside B o d e n h e i m e r.

F. T. K. P.

F. Neave. "Principles affecting the size of pink and chum salmon populations in British Columbia". Journ. Fish. Res. Board Canada, **9**, 9, pp. 450—491, 9 figs., 12 tables. Toronto, 1953.

The number of papers published on the fluctuations of the Pacific salmon would fill a fair sized library and indeed these extremely valuable commercial fisheries fully justify the amount of attention paid to them. Many of the papers are merely factual and I would not minimize their importance on this account, but they do not provide that stimulus to further thought that is the attraction of scientific literature and discussion.

Dr. N e a v e, however, in his account of two species of salmon in British Columbia enunciates certain principles of general biological interest which are important and thought-provoking. These salmon have a two-year cycle; a large catch one year is followed by a small catch the next and the smaller by a large catch the year after. These alternating catches continue over a period of years but, in addition to these annual fluctuations, from time to time the odd- or even-year catch will take a sudden jump upwards or downwards and will remain at the new level over a series of years. It is this sudden jump in population level which Dr. N e a v e sets out to explain.

He points out that the population levels are determined by the combined effects of three types of mortality — (a) mortality which becomes relatively heavier as populations increase in density, (b) mortality which becomes relatively heavier as populations decrease in density, and (c) mortality which is independent of density. The first kind of mortality, which happens to be the one that has attracted the attention of most biologists, has, of course, a levelling effect and would tend to equalize even- and odd-year runs as well as to reduce irregular fluctuations, and Dr. N e a v e therefore examines and assesses the effect of the other types. He particularly emphasizes the importance of the brief period when the young fish are migrating to the sea. During this time they are subject to predation which cannot be related to the abundance of the prey, for it is only temporarily that the predators utilize this sort of food. Consequently a large population of migrants should be relatively less affected and a low population relatively more affected. So a good hatch will

produce a better crop and a poor hatch a worse crop than the average relation between egg production and adults produced would lead us to calculate. Equally a big year-class would be expected to persist over several generations, for it would maintain this advantage over its predators.

The reviewer has stressed this aspect in his paper perhaps to the neglect of a very complete study of the other kinds of mortality, but the reader must not suppose that the paper is deficient in its consideration of these. It is indeed a well balanced study of the problem, which is worth the attention of all animal ecologists, whether they are interested in salmon or not.

Dr. Neave has proposed names for these different forms of mortality but perhaps I may be allowed to express a respectful hope that someone will find better ones before very long. *F. T. K. Pentelow.*

J. W. Jones and **G. M. King.** "The spawning of the male salmon parr (*Salmo salar*, Linn. juv.)." Proc. Zool. Soc. London, 122, Pt. III, pp. 615—619. London, 1952.

This is one of the most important papers published to date on the subject of the spawning habits of the Atlantic salmon. During the course of a series of experiments adult male salmon were rendered incapable of producing milt. The castrated males went through all the motions of spawning, a description of which has been given by these authors previously.

During the spawning process, one or more male salmon parr were in attendance on each spawning pair of entire female and castrated male in special tanks.

The experiments showed that the salmon parr had successfully fertilized 97·7 % of the ova discharged on one occasion. It is now clear that male salmon parr can and do take part in the spawning of salmon and the authors suggest that this is an additional safeguard in ensuring a high proportion of fertilization of ova.

The fact that male salmon parr can and do fertilize salmon ova must have a profound bearing on the old idea of "like breeding like" and the authors suggest that salmon "races" or "types" are not necessarily a question of parentage but of environmental conditions in their rearing grounds and later feeding grounds in the sea, a view which the reviewer of this paper has been inclined to advocate for many years. *A. E. J. W.*

H. C. Davis. "On food and feeding of larvae of the American oyster, *C. virginica*." Biol. Bull., **104**, 3, pp. 334—350, 5 figs. Lancaster, Pa., 1953.

Though many of the earlier workers found it extremely difficult and hazardous to rear bivalve larvae in the laboratory, dense cultures of a variety of species have recently been grown with success in the laboratory of the U. S. Fish & Wildlife Service at Milford, Connecticut. As judged from the papers presented by the staff and from direct information, the rearing of such bivalves as *Venus mercenaria* seems to be a matter of routine at Milford, and is practically always successful. The rearing of the American Atlantic oyster, on the other hand, was apparently more difficult and often led in the beginning to inconsistent results.

In his present paper on the rearing of oyster larvae in the laboratory Davis clears up many of the discrepancies between the results obtained at Milford and the experience gained elsewhere. As several workers elsewhere found it impossible to obtain consistently good results with the technique

developed at Milford, Davis's analysis is very welcome indeed. He demonstrates that the famous "mixed-*Chlorella*" culture used as food in the Milford laboratory only leads to satisfactory results because of its mixed character. When a pure culture of the very same *Chlorella* was given, the larvae did not grow at all. Evidently the flagellates present in the culture provided the crucial food for the young larvae, but once the oyster larvae had attained a size of approximately 125 μ they appeared to be able to utilize *Chlorella* itself as food. Several marine bacteria were tested, but none of those appeared to constitute a suitable food for oyster larvae. Several species of flagellates tested appeared to be utilized as food by the larvae, but others were not.

Rearing experiments in which both the number of oyster larvae and the number of flagellates added daily were kept as constant as possible led to the conclusion that there is a specific difference in food value; further, that several combinations of flagellates did not provide a more balanced diet than did pure cultures of the single flagellate species. It is also of interest to note that the value of certain flagellate cultures may vary considerably, because of day-to-day fluctuations in the physiological state and in the purity of the cultures used as food.

The finding of an inverse relation between the concentration of larvae and their rate of growth when a fixed number of flagellate cells was added daily throws some doubt on the assessment of the specific food value of the flagellates tested, as in those experiments (5000 larvae per litre, 10,000 flagellates added per c. c. per day) the quantity of food may have been the limiting factor, so that differences in the total *volume* of food cells available may not have been properly distinguished from real differences in dietetic value.

Despite this, it would still be amazing that rearing experiments should so often meet with failure elsewhere, had not Davis's analysis demonstrated that apart from the food factor there is also a thus far rather mysterious factor in the quality of the water which must be taken into account. Both differences in the unfed controls during various periods, and considerable differences in peak densities of the flagellates reared as food, indicate that this must be ascribed to some unknown physical, chemical, or microbiological constituent of the sea water used. Davis rightly adds that we do not yet know what this "water-condition" is, nor whether it is the presence of some inhibitory or toxic substance that causes poor growth, or the lack of something necessary to good growth. Little is explained by Davis's conclusion that one phase of the action of the unknown factor may be to affect the ability of the larvae to utilize the food available. Could we not say the same of every organism which lacks some vital constituent (e. g., vitamins) in its food, or which suffers from some kind of intoxication? As we ourselves have repeatedly experienced, the fact that larvae of *Venus mercenaria* and of *Mytilus edulis* fail to develop normally into veligers (i.e., before the food factor comes into the picture), while eggs of the very same batch develop normally in water of different origin (but otherwise apparently of identical quality) indicates that it is not only the ability to digest and utilize the food which may be affected.

We feel sure that further analysis in experimental rearing of bivalve larvae will ultimately reveal the factor which makes the water near Milford so very suitable for this work, and may be responsible for repeated failure elsewhere. Only then may we all hope to be able one day to carry out the rearing of bivalve larvae as a matter of routine. *P. Korringa.*

Current Bibliography.

Prepared by the Editor with the Assistance of Mr. A. R. Margetts.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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